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Rec. May 29. 1849.

THE
THEORY AND PRACTICE
OF
BREWING
ILLUSTRATED.

LONDON:
GILBERT AND RIVINGTON, PRINTERS,
ST. JOHN'S SQUARE.

SECOND EDITION.

THE THEORY AND PRACTICE

OF

BREWING

ILLUSTRATED:

CONTAINING

THE CHEMISTRY, HISTORY, AND RIGHT APPLICATION OF ALL BREWING INGREDIENTS AND PRODUCTS;

A FULL EXPOSITION OF THE NEWLY DISCOVERED PRINCIPLES OF CONVERSION AND EXTRACTION IN THE MASH-TUN;

THE PHILOSOPHY OF CLIMATE, SEASON, AND SITE;

CRITIQUES ON THE *MODUS OPERANDI* OF FERMENTATION, AND THE EFFECTUAL PREVENTION OF ACIDITY:

ALSO,

Many new Practical Observations

ON BREWING

LONDON AND DUBLIN PORTER, EAST INDIA PALE ALE, EXPORT STOUT, &c. &c.

William

BY W. L. TIZARD,

PROFESSOR OF BREWING, NINE ELMS, LONDON.

LONDON:
SOLD BY THE AUTHOR.

1846.

PREFACE.

SUBSEQUENTLY to the appearance of his former edition, the Author has been accused of having introduced technicalities and chemistry into his work, and he considers the charge to be somewhat oddly preferred; for, with regard to the former section of it, he is at a loss to conceive how a technical undertaking can satisfy, when deprived of its technical diction; for it must naturally resemble beer from which the alcohol has been abstracted, the one being thereby rendered too stale for the reader, the other too insipid for the drinker, and both altogether lifeless and dull.

Again is the promised volume of the magnitude by many thought bulky; for though it contains less of quotation, and many of the minor and less practical observations contained in his maiden production are here omitted, much new, curious, and valuable matter will be found herein, which an appeal to his Index, as an analysis of facts and observations, will fully testify;

and it must be evident that many of the subjects cannot be curtailed without spoliation; and with respect to compilement, the writer trusts that the ample scope which he has afforded to the merits of others in displaying the novelties of their several inventions, where in coincidence with his own views, will exonerate him from the grievous tax of concealed plagiarism on the sinister hand, and from the galling burden of self-conceit and egotistical gratulation on the other, and in some measure atone for the protracted appearance of his pages. Indeed, some small items enumerated in his prospectus have, on more maturely weighing them, been purposely omitted, among which, in particular, is "bottling;" a subject too devoid of art or interest to deserve any peculiar attention. Compensation for these trivial omissions is amply made in the new matter which is inserted gratuitously, and without prior notice.

With regard to chemistry, which some pronounce to be "too scientific for practical men," the author must beg to dissent in his explicit opinion from any doctrine so vaguely inconsistent. In all spheres and stations of life individuals may be encountered, the ability of whose thought and action is not competent to qualify them for the post they are intended to occupy, some of whom bask as securely in the connivance of interested friendship and undue patronage, as others will thrive through the indifference or ignorance of their principals; and to such as these does science appear as criminal as its attainment is formidable.

Many operative brewers, some of them in a few of

the largest town establishments, even now ridicule and despise the idea of chemistry being in any way connected with the art of brewing. Such instances of misapplication in men's services are but melancholy subterfuges, inasmuch as they act injuriously and unjustly on a better class, by excluding them from offices for which their superior talent exclusively befits them; and besides, this reckless mode of appropriation perpetuates vain bigotry and an enormous waste of property, all of which the enlightened and cultivated mind would studiously avoid; and thus the progress of the useful arts is impeded, and their promoters are ungenerously maligned by a dark spirit which knows not the limited range of its own chaotic capacity. Better far would it be for business, were such obstructors returned to the wash-house, or transferred to some other more congenial vocation, than be allowed to deceive and injure their employers and the public, and continue to misrepresent and deride their superiors, merely because "their capacity is too limited to understand one-half" of that which is addressed to them for their own good.

Surely brewers ought not to be less intellectual than farmers. Let those who are self-sufficient enough to scorn the idea of the necessity of chemical improvement run through a few modern books, subscribe to a periodical or two, attend a series of lectures on agriculture, read the farmers' newspapers, peruse the "Journal," &c., visit their public halls and reading-rooms, inspect their newly invented machines and implements, their

improved and scientifically arranged homesteads, well-tilled lands, and luxuriant crops; and if then their own convictions do not cause them to blush, they must really be unaccountable creatures. Let such reflect that the time has long since arrived when it is necessary that mere manures should be analysed, and their components minutely advertised, to enable the husbandman to purchase according to his especial purposes; for nothing but his newly acquired and inestimable knowledge could ensure the right application of any particular compost, to suit it to the nature of the soil and of the seed to be sown within it. That person must be most obdurately deficient in judgment who cannot, after such free enquiry, pronounce science to be a progressive vehicle, and that, too, the most powerful ever introduced to civilization. The universal and important application of chemistry must ere long force itself upon the convicted minds of the people, and, through their instrumentality, upon the attention of government, till within the course of a very few generations this branch of the sciences will, with others, be cultivated as generally by all classes as writing and arithmetic now are; indeed, a youth's education is not at present considered complete without some smattering of the art.

The precarious state of the author's health, and the expediency of personally superintending the erection of his patent machinery in various places, have caused some little delay in the bringing out of this edition; but he imagines that the appearance of his smaller work, the "Voice from the Mash-tun," in the com-

mencement of the past summer, relieved the anxiety of some of his friends respecting the success of that important feature of his solicitude, and obtained for him the patience of others, for which he hereby thanks them; and he hopes that this plain statement of circumstances, unavoidably true, will appease any apprehension of their censure which he may have entertained. On other topics to which his original preface referred, he will now be silent. As an author, he is fairly before the world; and as an inventor, he knows the range to which his principles have been carried into action; but in neither capacity has he any desire to be bombastic. If his apparatus are accurate and their results steady, and if he continues to be honoured by the testimonials of first-rate men in his profession, the issue will be sufficient within itself to supersede the use of boasting on his own part. His object from the first and throughout, has been to make himself useful to society by means of new discoveries calculated to benefit the community at large, and to commit his errors in thought or practice to correction by future experience and improvement; being well assured, that as his theories become old, his practical operations will be modified by the wisdom and skill of others, and both will be bettered accordingly, as the progress of knowledge follows the dictates of expanding art, befitting the intelligence of a judicious world, brightened by gradual cultivation. With this prospect he has recommended such alterations as are useful, attainable, and profitable, whether his own or not, in order to posite a step in the staircase of literary

advancement, to be repaired or reconstructed as new interests in scientific or mechanical productions become excited and perpetuated.

For the edification of young beginners, a copious Lexicon has been appended on derivative principles; and the tables which were composed for the first edition have been carefully revised, most of them remodelled, and several new ones added, on the presumption that they are truly serviceable; and the analyses and specific gravities of bodies, which are of the first consequence in practice, have been reconsidered and compared with the expressions deduced by the highest and most recent standard authorities, and adjusted accordingly. Saccharine juice, in particular, a substance long held in doubt and dispute, has claimed much of the author's vigilant attention; and his conclusion has been deliberately formed, and can scarcely be deemed extravagant, when it is admitted that a cubic foot of sugar-loaf, which is not a perfectly compact solid, has been determined to weigh 1606 ounces; which countervails all arguments which would fix solid saccharum at any lower ratio; and surely it cannot be unreasonable, were more perfect proofs wanting, to allow an increase of 19 for complete densification. This being all that is requisite to be advanced in reference to particulars, he reposes his generalities, with some degree of confidence, in the hands of his impartial readers, thanking them for their attention, and his subscribers for their patronage and good opinion.

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ERRATA.

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8,	6,	*pro* eared, *lege* bearded
32,	17,	*lege* Aviciennes
57,		*Table of albumen*, *pro* 7·55, *lege* 7·85
342,	32,	*after* freezing *add* point
402,	10,	*lege* humuslike
417,	4,	*pro* grain, *lege* brain
490,	1,	*pro* fresh, *lege* from
497,	5,	*pro* roasted, *lege* roasting

THE

THEORY AND PRACTICE

OF

BREWING ILLUSTRATED.

CHAPTER I.

INTRODUCTION—THE PATENT; ITS PURPORT AND PROGRESS—OLD NOTIONS—HISTORY OF BREWING—CURIOUS CUSTOMS—DERIVATIONS AND CRITICAL REMARKS—DISCOVERY OF DIASTASE—SCHEMES AND FAILURES—REMEDY SUGGESTED.

WISELY has Locke said, in his Essay on the Human Understanding, that "No man is under necessity to know every thing; but they that have particular callings ought to understand them." For this saying, which in its original dress is probably as old as the Brewer's art, he appears to have been indebted to the ancient precept attributed by scholars to Pittacus of Mitylene, and handed down to successive ages as one of the *dicta* or *maxims* of the seven wise men of Greece, which says, "Understand the occasion;" or it is more freely rendered thus: "Be clear in the cause which you undertake, and correct in the manner of conducting it." Somewhat similar to this is the motto of Solon, the Athenian lawgiver, "Know thyself;" and a third of those venerable sages, Periander, used as his proverb

the undoubted truth, that "With industry nothing is impossible." One expression more, which is nicely in place, and brings us home more intimately to our native land, and the heroic achievements of our own times, is the injunction given by the immortal Nelson to his disciples in his dying words: "England expects every man to do his duty." Sentiments of this nature deserve the utmost regard; and hence it is that the author and compiler of this treatise, excited by a desire to pursue a task enjoined by the inspiring manifestation of courageous zeal, and having his mind stamped with deep impressions, received within the space of sixteen years, during which he has been practically and extensively occupied in the superintendence of the Brewery, has studiously endeavoured to imbibe the sublime essence of philosophy, as far as applicable to his profession, in order to possess himself of adequate ability to fulfil his engagements, and to impart practical and rational information to others. How far his efforts have been successful, the following pages are intended to show, especially to such as may be disposed to doubt the reality of that share of public approbation which already has arisen from his exertions.

Her Majesty having granted him her "Royal Letters Patent, License, and Protection," for the introduction of his several inventions to facilitate and improve the Art of Brewing; he, in calling the attention of society, and especially of Ale and Porter Brewers, Distillers, and Vinegar Makers, to the various instruments that he has invented and successfully introduced, and which constitute, in the opinion of those who work them, a series of machines, implements, and utensils, of the greatest possible benefit to THE TRADE, sees at once the necessity of upholding his Patent-right by protecting all who favour him with their orders, as well

as detailing, for general instruction and public satisfaction, the principles that he has acted upon in accomplishing the means by which each respective portion of his apparatus compasses the purpose that he has had in view while attending to its especial department in the establishment. Many, especially among young Brewers and gentlemen termed sleeping-partners, may lack necessary practical information to a certain extent; and the opinions of more experienced men following the "copper side," backed by the doctrines of chemists of standard celebrity in the scientific world, may be of real service, while they are acceptable to him as corroborative evidence of the utility of his system, now completely reduced to practice through the completeness of the mechanism which sustains it. For his own part, the testimonials which he has selected for insertion in the present volume, added to his own knowledge of the quantity and quality of extract produced by his own machinery under his own eye, and by others who employ it, completely convince him of its extraordinary powers; and no other guarantee is wanting to reconcile his own mind to a continuation and extension of the principles that he has wrought out.

Still, all demonstration is useless, unless it be powerful enough to displace hastily-formed prejudices, or to remove from the conviction the effects of former and weaker evidence. The remark has been made, that practice without theory is like music without notes; and it is the discord and confusion of ideas that is now sought to be rectified in the Brewery: consequently the task, however arduous, *must*, and the author flatters himself that it *does*, accord with correct principles, which require to be kept in harmonious order.

Although his apparatus and its effect are open to inspection and inquiry, wherever erected, in town or

country, and though he might content himself by reference to the several establishments where it is at work, for a clear comprehension of its merits, (and such a short course might, in a pecuniary sense, afford immediate and ample satisfaction to some inquirers,) yet, in a state of society like the present, when philosophy and trading enterprise travel with giant strides round and through the land, and when the demand for scientific aid is loud and peremptory throughout every branch of the arts and manufactures, the act of witholding theoretical and useful information from a thirsty world would be as criminal as the publication in darker days was foolish; and were the exposition of the wonderful merits of the newly-detected substance called DIASTASE the sole motive for the present author's intrusion on a reading and thinking community; that alone, as a means to an important end, would lead him to the task of fully and fairly developing its properties to the Brewer, whose trade, as a science, is but in its infancy, though there were Brewers in Solon's day, 2400 years ago.

Many are forward enough to observe, and perhaps to contend, that the ideas of persons who have written on this old subject cannot be new; and the doctrine is good as far as it goes; but new men have novel notions —perhaps not altogether founded on any that have had prior circulation. When the hydrometer first came into use, one of its ablest advocates expressed an idea in print, that the saccharine matter contained in the extract of malt was not more diminished by the *very small quantity* of mucilage which mixed with it when drawn from the mash-tun, than the sugar was weakened by diluted particles of hydrogen, or water, and averred that mucilage was a necessary ingredient in worts; but surely such ideas cannot obtain support in the present

generation. Another well-received notion, because anciently held as a good dogma, was, that though all things may change, nothing is new; which is equivalent to saying, that a man never wears a new coat. Two or three questions will settle the absurdity. Is the patent new? Can the invention for which it was granted be otherwise than new? Are its purposes unchanged from old practice? Is diastase a new discovery? Is a lymphine fermentation in wort an old theory, or any portion of one? Is the transmutation of mucilage into beneficial and pure saccharine matter new? Is the conversion of starch, hordein, and hops, by steam, and the salvation of the essential oils, new? Is the *desideratum* of a constant temperature new in practice? Is an additional saving of 5, 10, or 15 *per cent.* new? These are points for examination and reflection, notwithstanding the saying which has existed from time immemorial, that "any old woman can brew;" which is no argument to the purpose; for so could the Armenian matrons, in their little way, before Socrates was born. A certain censorious, but not over-polished or too scrupulous critic, who is editor of a species of almanack, informs us, in his number for 1844, that "Xenophon, in his account of the retreat of the ten thousand Greeks under Cyrus, 400 years B.C., tells us, that, coming to the western part of Armenia, the governor was Teribazus, the houses were under ground, the mouth resembling that of a well, but spacious below. There was an entrance below for the cattle, but the inhabitants descended by ladders. In their houses were goats, sheep, cows, and fowls, with their young. All the cattle were maintained within doors with fodder. There were also wheat, *barley*, legumens, and *beer* in jars, in which the *malt* itself floated even with the brims of the vessels, and with it *reeds*, some large and others small,

without joints; these, when any one was dry, he was to take into his mouth and suck. The liquor was very strong when unmixed with water, and exceedingly pleasant to those who were used to it."

To this he appends a note, in which he adds, that the *beer* above described was called **Οἶνος κρίθινος** [Oinos krithinos], literally "*barley wine*," and the interpretation is correct, whatever the date may be; but Cyrus, after his conquest of the whole known world, was made king of Persia B.C. 559. The note goes on to assert, on the authority of Diodorus Siculus, that "Osiris, that is, the Egyptian Bacchus, was the inventor of malt liquors in those countries where vines did not succeed, which is the reason assigned by Herodotus for the Egyptians using it." So says Thomson, and that Herodotus was *born* B.C. 444: we copied him, the "Annual" has read us, and the error is palpable. Herodotus, who wrote of things from hearsay, *died* B.C. 413; but there were vines in Egypt when Joseph was there, as we read in Genesis, chap. xl.; and Joseph died B.C. 1635, at the age of 110, which was 82 years after he interpreted the dream of the grapes (Gen. xli. 1 and 46); so that Herodotus and the almanack have shot with too long a bow, and carried the *Oinos krithinos* subject considerably beyond the *butt.*

Still, however, old women can brew, and so can the redoubted, but clumsy critic; though, when we meet with thousands, aye, and millions of barrels of beer quite unfit for drinking, we do not thence conclude that every old woman is fit to brew, and much less that the generality of such women can brew perfectly, or at all advantageously. Few old women, even in literature, are chemists; fewer chemists are brewers; and fewer still are the brewers who, by attention to chemical transformations and chemical constituents, have been

able to increase the quantity of the useful extract from malt, and to reject the errors, both in theory and in practice, that eventually reduce the labour of the old-woman brewer to futility and loss. The author adheres to this sentiment, notwithstanding any rude remarks which may appear in the columns of the "Annual" on "theories" which the editor chooses to deem impracticable; for he that sits within the copper knows more of its ebullitions than an outsider who jumps up at the edge to catch a peep at the interior.

The critic goes on to say, that "this was also the liquor used in *France* till the time of the emperor Probus, when vines were first planted there;" and that "Julian, who was governor of *France* before he was emperor, vented his spleen against malt liquor, which necessity, or rather ignorance, in his time, had made the drink of that country." This is probably true as to the fact, but not as to the letter; for Julian was emperor in A.D. 193, and Probus in 276, but *Gaul* was not called *France* till after Pharamond had subdued the Visigoths in that country in 448, the year before Vortigern invited the Saxons into Britain, when the Romans had held this country 400 years.

Gr. **Οἶνος** (Oinos), Lat. *vinum*, Eng. *wine*, and **Κριθινος** (Krithinos), *hordearius*, barleyan, from the root **Κριθη** (Krithee), *hordeum*, barley, are the two words used by Xenophon, who died B.C. 359. Dr. Thomson, who refers to the Euterpe of Herodotus, c. 77, for the above account of the Egyptians, adds, that "in the time of Tacitus, whose treatise on the manners of the Germans (*De moribus Germanorum*, c. 23) was written about the end of the first century of the Christian era, beer was the common drink of the Germans. Pliny (Nat. Hist. lib. xxii. c. 25) mentions beer as employed in Spain, under the names of *cœlia* and *ceria*, and in

Gaul under the name of *cerevisia.*" He then proceeds to explain, that "almost every species of corn has been used for the manufacture of beer. In Europe it is usually made from *barley;* in India, from rice; in the interior of Africa (according to Mungo Park), from the seeds of the *holcus spicatus*" [spiked or *eared* wall-hardy].

Some of these observations are borne out by other authors of antiquity; and the *cerevisia* of Pliny evidently takes its name from *Ceres*, the goddess of corn,—lexicographers doubting whether it ought not to be written *cererisia.* Plautus more minutely calls it *cerealis liquor;* that is, liquor used at the solemn feasts in honour of that goddess,—the "*harvest home;*" and both he and Columella, a famous writer on agriculture, who flourished in the reign of Claudius, and consequently whose work is coeval with the invasion of Britain by that emperor, called this liquor *zythum*, which, if we trace it to its Greek origin, is there written Ζυθος (Zuthos), and is interpreted by Schrevelius thus: "*Potus ex hordeo, cerevisia;*" DRINK FROM BARLEY; and he works out the derivation from Ζυμη (Zumee), *a ferment*, which again descends from Ζεω (Zeo), to *seethe* or boil, and hence also our word *sea;* but the erudite almanack-smith thus defines it: "Pliny says they called it *cervisia*, a word *probably* derived from *cervoise*, which among the ancient Gauls signified beer."

BARLEY.—That barley, the *hordeum vulgare* cultivated in Britain, was known to the Romans, is evident from Virgil, who uses it plurally, *hordea*, as we do the word *oats;* and Pliny tells of the *hordearii gladiatores*, a kind of fencers, whose sustenance was *barley.* Authors again write, that when the Romans were in Britain, they found there a species of *wine* made from this kind of corn, by the aborigines called *baer*, which in excellence of

flavour and quality surpassed all the wines of Rome. Hence, though they possibly mistake Britain for Germany, the English word *beer*, and its ferment, *barm*, with an oriental termination; but the latter part of the word bar-*ley* relates to the field in which it grows, rather than to the corn, and is purely Anglo-Saxon; and certainly Cæsar found little of the *cerevisia* here; for he says (Bel. Gal. iv. 14), "Interiores plerique frumenta non serunt, sed lacte et carne vivunt." (*The more inward for the most part do not sow corn, but live on milk and flesh.*) Whatever, therefore, the Roman soldiers found, was necessarily in small space, and with due deference to them in the sense of taste, was perhaps as nectareous as that which modern topers term "dipup," "bastard vinegar," or "whistle-belly," of which he who has the most has the worst share; for though it might have been "*potus coctus*" (cooked or boiled drink), and bears, as such, the flavour of antiquity, it had nothing in its nature partaking of modern brewing principles, or that emanated from such, however fine and choicely *bouqueted*. Custom is not always easily accounted for. The Britons drank mead till the introduction of agriculture by the Romans, and many are the encomia passed upon it in the songs of their bards; but the Roman farmers undoubtedly found the soil suitable to the growth of barley, on comparing it with the lands of France and Germany, which they had visited in their progress. A record of brewing in the fifth century says, that the grain was then steeped in water, made to germinate, and was afterwards dried and ground; after which it was *infused* in a certain quantity of water, and then fermented, when it became a pleasant, warming, strengthening, and intoxicating liquor; and that it was commonly made from barley, though sometimes from wheat, oats, or millet. This is all that we know of the Romano-

British brewery; leaving, therefore, the Roman arts and the Roman glory to take their spread over a conquered country as civilization matured and good faith became mutual and common, we come to the days of the Saxons and Danes, who butchered and caroused here during the space of 617 years, or from 449 to 1066.

ALE.—In a work entitled "Domestic Life in England," we read, that when the Saxons inhabited these regions, they drank mead and *ælle* as their common beverage, using wine only as a medicine or a luxury. From this word *ælle* Dr. Johnson derives the more modern *ale*, which is still pronounced *yell* or *yal* in the northern counties, where many relics of Saxon manners, customs, and language remain; but *ælle* signifies *universal*, whence *all*; and ale seems to have been held in general request among that people. Ina, who was king of Wessex from 689, names the beverage *ælle* in his laws, which restrict the use of it; and by a law laid down by king Edgar the Pacific, who died in 975, the huscarles and guests were limited to half a pint at each draught, and tankards were made to hold two quarts each, and had pegs fixed one above another at proper distances, dividing the measure into eight equal portions, and certain punishment was inflicted on any one who drank beyond his peg; but when the surface had subsided to the centre of it, he handed the vessel to his next companion. When the Danes had possession of the country, they were most immoderate sots, and when a Saxon and a Dane drank out of the same bowl, each was *pledged* not to stab the other while drinking. This ale was fermented like their mead, differing from it only in being extracted from mongrel malt instead of honeycomb, and tinctured with herbs. In their revels they entertained harpers, gleemen, jugglers, and tumblers, who also frequented guest-houses and *ale-shops*, in which

women were the brewers; and even till as recently as the reign of Edward III., if a man attempted to bake, brew, or dye, he was considered an innovator. Chester ale seems to have been in great repute; for the Danes decreed, that any inhabitant of that city brewing bad ale should be placed in a ducking-chair and plunged into a pool of muddy water, or should forfeit four shillings. In the time of Edward the Confessor, mead sold at 16*d.*, spiced ale at 8*d.*, and *common* ale at 4*d.* the gallon; but we are not told what kind of spice they used.

Brew.—Most of our domestic words are derived from the Anglo-Saxon language, and particularly such as contain a *w*, that nation having introduced this letter into the island, though, according to Johnson, the word *brew* is of Dutch origin, and signifies to *cook;* and we find that with the ancient Romans a Brewer was designated *cerevisia coctor*, or *cooker of beer.* That eminent chemist, Dr. Thomson, says, in his section on Vinous Fermentation, that "under this name is comprehended every species of fermentation which terminates in the formation of an intoxicating liquid. Now these liquids, though numerous, may be comprehended under two general heads, namely, those which are obtained from the *decoctions of seeds*, and those which are obtained from the *juices of plants.* The liquids of the first class are denominated *beer* or *wash;* those of the second *wine.* Here are two more brewing words, each beginnign with *w;* and a third is *wort.*

Mash.—As to *wash*, which the Saxons would write *wæsh*, or perhaps *wæsc*, its general termination, *ash*, implies something loose, as *mash*, *lash*, *smash*, *crash*, *sash*, *fish (fisc)*, *desk*, to *ask*, and the *ash*-tree, which grew detached from the group of the forest. *Mash*, which Johnson takes from the Dutch *masche*, has something extensive implied in its initial letter, and so have

marshes, *marches*, and the *meshes* of a net ; and a *mash*, whether of culinary vegetable roots or of malt, is synonymous with a comprehensive *mass* or *mess ;* and the mode of *cooking* such a mass by *soak* or semi-distillation, which is a way of nursing it into solution or digestibility, is *brewing* it, whether performed in a mash-tun, a teapot, a vegetable steamer, or if it be a collection of soluble vapour concocted in a cloud on the mind. Such is the plain meaning of the words *mash* and *brew*, with which most good housewives are practically acquainted in one way or other.

MALT AND WORT.—These words also are Anglo-Saxon. *Malt* signifies any thing *malled*, being a mere curtailment of the word, as *wort* is of *worked*, and scores are like them. In the old herbals, descriptive of plants that were brewed into medicinal *drinks*,—which *drink* is another Saxon word importing the act of imbibing, as well as the matter *sucked* in, and which drinks were much used anterior to the introduction of hops and malted barley,—we read of ragwort, spearwort, spleenwort, and crosswort, all so called from the shape or position of their leaves ; and of mugwort, figwort, and moneywort, from the structure of their seed-vessels ; while pilewort has its title from the resemblance of its roots, bloodwort from the colour of its leaves ; and some have their names from the effects they produce, as sopewort, pepperwort, butterwort, and sneezewort ; but more from the efficacy ascribed to them in curing various diseases or infirmities of the human frame, as lungwort, liverwort, rupturewort, barrenwort, birthwort, motherwort, goutwort, bladderwort, stammerwort, throatwort, and woundwort ; and some were pre-eminently dedicated to their titular saints, as St. John's, St. James's, St. Peter's, all in consequence of the virtues they were said to possess when put to *work* within the human or other animal

body ; and surely *staggerwort* must have been as potent as any.

To proceed to the history of the wort prepared by the brewer to *work* in the fermenting vat, and those "decoctions of seeds" by which it is produced: the Saxons and Danes were no great improvers, and consequently we may infer that the art continued with them much in the same rude Britico-Armenian state in which they found it, especially as the Normans did not stumble over any brewhouses or malthouses when they compiled the register of Domesday, though where they met with a *molin* (or miln) they valued and booked it ; nor were the English likely to exert themselves while under the Norman subjugation, which lasted till the signing of Magna Charta in 1208. In fact, the Normans reduced the Danish gluttonous habit of four heavy gormandisings a day to two abstemious meals ; but it is recorded of a certain bishop of Ely, in the reign of Henry I., that his table was replenished daily with "all sorts of beasts that roam in the land, of fishes that swim in the water, and of birds that fly in the air," and with beverages of French wine, spiced mead, mulberry hypocras, pigmait, claret, morat, cider, perry, and *ale ;* and we also learn, that in the days of Henry II., whose two meal-hours were nine in the morning and five in the evening, his richer subjects regaled on wine and mead, but the poorer class drank cider and *ale* In the reign of Henry III. the price of ale was regulated by that of corn and wine, and the women who brewed it sold it at a penny a gallon in the cities, and at the rate of three or four gallons for a penny in rural places.

BEER.—LOUVRES.—Whether some alteration took place about this period in the mode of brewing, or whether malting was commenced upon a new and enlarged plan, it may be difficult to say ; but many novelties were

now introduced from abroad, and the wings of commerce began to expand. A brewhouse or malthouse ventilating blind is called a *louvre*, which is a Norman word, and consequently not of recent introduction, but seems to have come with the influx of improvements, though the brewers may have borrowed it from the tanneries. The old British word *beer* was also revived in this or the following reign, and seems to have superseded the ale of Saxon, Danish, and Norman make; for in the 17th of Edward I., *anno* 1289, amongst the charges for a man of rank travelling from Oxford to Canterbury with a retinue of six attendants, are sixpence for *beer* and a halfpenny for apples, whence we may presume that they had "lamb's-wool" for supper, and that the master was an ecclesiastic. On the following day, which was Sunday, is a charge of 12*d.* for *beer* "for my lord at Westminster, when he held a breakfast there for knights, *clerks*, and esquires," besides "two gallons of *beer* for the boys, 2*d.*" Edward III., after passing a severe law to restrain eating and drinking, gave an entertainment of thirty courses, called dinner, at nine in the morning, the fragments of which fed 1000 poor people. We have no account of the drink consumed; but after dinner they had confections of cloves, cinnamon, grains of paradise, ginger, &c., for dessert, which shows the kind of condiments to which the spicers and adulterators of those ages had recourse.

Under Richard II., malt liquor was drunk at breakfast-time; and that king, in 1389, gave a housewarming to 10,000 guests in his new hall at Westminster, which he had rebuilt, and where he kept Christmas, the breakfast consisting of boiled beef, sprats, herrings, brawn, bread and butter, mustard, malmsey, wine, and *beer;* and this kind of fare then became common among the gentry, the monasteries grew into great note for their

superior brewing, as did the colleges after them, and men had become brewers, having taken pattern from king Richard's 2000 cooks. In 1421, one William Payne, of the Swan, in Threadneedle-street, London, refused to send a barrel to Henry V., then in France; and report says, that in the following year the celebrated Whittington, who had been lord mayor in the last year of Richard's reign, 1398, informed against the Brewers' Company for selling their *ale* too dear, and had them fined 20*l.* by the lord mayor then in office. From this time aleconners were appointed to inspect the measures; and two years afterwards, being the second of Henry VI., the company had grown to sufficient consequence to be incorporated. In the reign of Edward IV., at the installation of archbishop Neville in the province of York, among other extravagances enumerated, were 300 tuns of ale; and Edward himself gave breakfasts of bread, salt fish, and *ale*, to his nobility, at seven in the morning, dined at ten, and sat three hours, with a side table appropriated expressly to wine and ale, which were handed to the guests in goblets of pewter, wood, or horn; supper was served at four; and at nine, lords and ladies had *liveries*, or collations, with a gallon of *beer* and a quart of warm spiced wine to each; and there appears to have been a difference between the *ale* with which they broke fast and the *beer* on which they supped.

Brayley, in his "Londiniana," vol. iv., informs us, that in the churchwardens' accounts of Allhallows Staining, in London, in which Ironmongers' Hall stands, is the following entry, made in 1494: "Payd for a kylcherkyn of good ale, wyche was drunkyn in the Irynmongars' Hall, all charg's born, 12*s.* 2*d.*" It must have been *truly* good; for the same author has also discovered a bill of fare for fifty people of the Salters'

Company, dated 1506, and preserved as a record in the waiting-room of their hall, in which one of the items is, "1 kilderkin of ale, 2*s.* 3*d.*"

The great earl of Northumberland, in the time of Henries VII. and VIII., who had a family of 200 persons, allowed each of them a quart of *beer* and another of wine to breakfast every morning at six, and another of each to dinner at ten. Meat, drink, and fire, were then calculated to cost 2½*d. per* head daily; and malt was sold at 4*s.* the quarter, which brewed two hogsheads.

BREWERIES.—No deal of sagacity is requisite to perceive that these establishments sprang up, though not of such magnitude as at present, when men began to take the trouble of brewing off the hands of the women; for if there had not been a number of breweries in 1422, Whittington had not turned informer against the company. In the fifteenth of Henry VIII., alderman George Monoux was elected mayor of London, and fined 1000*l.* for "neglecting to appear after being divers times called upon by letter and otherwise," and next year, "on his petition and bill of supplication alleging his great age and feebleness, and offering to give *a brewhouse adjoining to the bridge-house in Southwark* to the city, in consideration of being discharged from the office of alderman, had the decree against him revoked, and his request granted, on some special conditions." At least, therefore, that notable "brewhouse" the Anchor, at London Bridge End, which now consumes a million of quarters in nine years, has existed more than 320 years, as the occurrence took place in 1524: the precise year in which the old distich tells us that

> "Turkeys, carp, *hops*, pickerel and *beer*,
> Came into England all in one year."

That is, beer of a new sort, qualified with hops, which

opens a new chapter in the chronicles of the brewhouse. Ale and beer, though in some places named synonymously, and in others indifferently, certainly never signified the same thing at the same time, though each may have changed character. *Ale* was the stronger of the two before this change of bitter, as it now is, though not in the same sense; for it now implies the first-drawn worts, whereas it was then a strong extract fermented without hops; but *beer* was a revived word, as before noticed, appropriated exclusively to liquor obtained through the application of the hop. Lance, in his "Hop Farmer," published in 1838, has the following explanatory document from a curious old book by Reynolde Scot, dated 1578 (20th Eliz.): "The hoppes shall be wholesome for the body, and pleasanter of verdure or taste than such as be disorderly handled. You cannot make above viii or ix gallons of indifferent ale out of one bushel of mault, yet you may, with the assistance of hoppe, draw xviii or xx gallons of very good beere; neither is the hoppe more profitable to enlarge the quantity of your drinke, than necessary to prolong the continuance thereof; for if your ale may endure a fortnight, your beere, through the benefit of the hoppe, shall continue a moneth; and what grace it yieldeth to the taste, all men may judge that have sense in their mouthes; and if the controversie be betwixt beere and ale, which of them two shall we place in preheminence, it sufficeth for the glorie and commendation of the beere, that here in our own countreye ale giveth place unto it; and that most of our countrymen doe abhorre and abandon ale as lothsome drincke; in other nations beere is of great estimacion; and of strayngers entertayned as their most choyce and delicate drinke; without hoppe it wanteth its chiefe grace and best verdur."

In the grand carnival, when Robert Dudley entertained the queen at Kenilworth Castle in 1575, the *ale* there consumed was 365 hogsheads, the value of which at that day, according to Holingshed, was five gallons for a shilling; and in 1586, when the queen of Scots was confined within Tutbury Castle, the conspirator Babbington, of Dethick, contrived to convey letters to her through a chink in the wall, the messenger being a brewer who supplied the house with *ale*. At that time Derby, whence the brewer probably came, had acquired a celebrity for its provincial produce which its neighbour Burton retains. Brayley notices it as a favourite beverage in the metropolis; for Sir Lionel Rash, in Greene's pleasant comedy of "Tu quoque," says, "I have sent my daughter this morning as far as Pimlico for a draught of Derby *ale*, that it may fetch a colour into her cheeks:" a proof that this hilarous beverage was accounted medicinal.

This, then, is the history of the brewery through embryo into life: all the rest has been growth. The mash, the hop, the working, &c., as general subjects, will be found more fully handled in their appropriate chapters; but here, be it observed, that if a bushel of malt would produce twenty gallons of good sound beer, or *ale* as it is now called, as early as the sixteenth century, and would keep a month on tap, it is much more than can be said of most ales that are brewed in the nineteenth; so that the brewer's art has not made great progress since the former period, notwithstanding all the books that have been written concerning it, and all the contrivances, whether inventive or alterative, that have been introduced to amend the process, though many are excellent in their way. The Elizabethan economists had in view flavour, quantity, quality, and preservation; and with these united, that *summum*

bonum of industry's desires—profit. If, therefore, brewing were as simple and unprecarious as some are willing to imagine, the author has a shelter for his essay in the wing of the great Herschel, who, in his discourse on the study of natural philosophy, says: "To the natural philosopher there is no natural object unimportant or trifling: from the least of nature's works we may learn the greatest lesson." Thus it is with the brewer: his taps, his fires, his heats, his yeast, his every thing, demand the nicest care; and even the misplacing of a bung or a vent-plug may involve him in serious consequences; and the sustentation of the action of diastase in a state of solution, is an art within itself that never yet engaged the attention of the old women of philosophy: it is the discovery of the French and German men of science, at whose schools our countrywomen have not matriculated.

The mere mixing and stirring of malt with heated water, without regarding the true principles of the art, may be called mashing; and this may suffice with many who brew, though it may lead them into hot water uncoolable. But the intelligent brewer takes into consideration the colour of his malt, its former situations in the field and the rick or barn; where possible, the quality of the land on which it grew, the mode of malting it, and other particulars; and having considered the relative value of his samples, he has regard to the strength, flavour, and general qualities of the potable extract to be made, and the locality of its subsequent destination; he also watches, with particular care and anxiety, the temperature of his solvent liquors, and the chemical change which is to take place in the organs of the bruised or broken grain when in contact with hot water. The many varieties of colour and constitution in malt liquors demand from the brewer an

equal diversity of varieties in the mashing heats; and the most skilful in his profession is frequently, through the temperature of the atmosphere alone, and often from other causes, prevented from mashing at the exact heats which, from experience, he knows to be proper. His daily observations, and consequent daily enlarged knowledge, most probably point out to him the paramount utility of the mash-tun thermometer, by which he ascertains the period when the lowered heat of the goods compels him to "set tap;" and he knows that the smallest mashes require the greatest limitation of time; yet, great as all his disadvantages may be, they are susceptible of very great increase, which to him is a consideration highly important; for another circumstance which ever exists in connexion with the first part of the process, and over which he has no more controul than his most ignorant workman, is his inability to increase, maintain, decrease, or vary at pleasure, the heat of the whole mash: a power which it is the first object of the present patentee to give, by means of his invention.

The great difficulty, hitherto insurmountable, experienced in endeavouring to obtain all the most valuable contents of the mash-tun, and those only, has led to many schemes and experiments, most of which have utterly failed; and the rest are so far blended with anterior practice in their nature and working, and have proved so inadequate to the purposes sought, that the establishment of a more satisfactory system has long been anxiously and earnestly desired. A recapitulation of the disadvantages that are felt and seen by men of business, would be a sheer waste of words: in truth, so dissatisfied are brewers with the peculiarities of each other, that not one of the methods yet projected has been thought worthy of general adoption; and the

writer knows, from his own practice, and from active correspondence in many parts of Great Britain, that the least objectionable plans hitherto adopted are, from the cause that has been named, so unsatisfactory in their results, that nothing short of a new *principium* is required in order to perfect the processes of mashing and fermentation.

Though the desirableness of preserving the heat of the mash is universally admitted, very few have had recourse to the only plausible arrangements that have presented themselves to their notice for that purpose; one of which consists in a double mash-tun, so constructed that the inner vessel or tub, containing the goods, may be surrounded with hot water or steam, contained within the cavity of the outer. This experiment has failed, because, if the heating medium were applied hot enough to affect the bulk of the mash, the outer parts of the goods would be overheated; and if the parts lying near the side were of the requisite heat, the gradual diminution of temperature from side to centre, would keep the latter too cold; and the existence of either too much or too little heat will cause a comparative neutrality, instead of action, among the most valuable principles of the grain, and will produce irreparable injuries in other respects.

Another plan which has been tried, and found unsuccessful, is the *admission* of steam through perforated pipes or valves, or its *circulation* through a continued series of pipes, *beneath the false bottom* of the mash-tun. This arrangement, though at first sight more feasible than the preceding, is still open to the same objection, namely, the extreme difficulty, indeed the absolute impossibility of equally and readily diffusing the increased temperature of the goods nearest the bottom through

the mass, the most efficient mashing-machine being inadequate to the great task.

An instance of the danger of such experiments recently took place at a large distillery near London, where a foreigner had been allowed, under pretence of effecting a great end by a little ingenuity, to introduce naked steam. The goods set, and the brewer was obliged to draw the wort off the surface of the mash; for such were the coagulation of the albumen, and the pasty consistence of the starch, that the liquid could not percolate. The loss was serious, and consequently the project was abandoned.

But though the promoters in general of the highly-essential object have been unsuccessful in their attempts, the accomplishment of their wish has been frustrated, not so much by the difficulties presented to the attainment itself, as by the inadequacy or unscientific application of the means employed; for had the experimentalists considered that caloric, in such a case, could only pass by transmission from particle to particle, and that all unmetallic fluids are bad conductors of heat, they would assuredly have preferred a contrivance such as that which is now, for the first time, before the public.

All bodies charged with surplus heat have a radiating and diffusive quality; therefore, they retain uniformity of temperature no longer than while they receive an uniform supply from other bodies in communication with them to replace the rays remitted to colder media, whether that supply be obtained from steam surrounding the sides of the vessel, or derived from submerged steam pipes. Now the present common system of mashing conveys the calorific principles, especially from the surface, much faster and much more

freely than they are supplied from below, where the intensity of the heat is preserved by its greater density; and hence the comparative coldness and consequent sourness, so often and so easily perceived upon the long standing of the tap, notwithstanding such precautionary measures as a layer of dry malt strewn over the surface, and marked with a cross "to keep the witch out of the tub:" a superstition fit for the reign of James I., of demonological memory, and showing to a certainty that intellect has been halting. Curtains and covers, too, are frequently used, in reliance on their defensive or reflective virtues, though the heat will partially ascend through such coverings; so that the tun still remains in an unprotected state. Some surround the mash-tun with sawdust or other non-conducting substance; yet their difficulties exist as before, from their inability, as in the other instances, to controul the mashing heat.

The majority of common brewers are compelled to waste many quarters of malt annually; and the most economical and ingenious are the readiest to confess this general truth, knowing that they fail in their efforts to accomplish a perfect and sound extraction. This must ever necessarily be the case while they remain destitute of the means at the author's sole disposal; and they suffer incalculable loss from the imperfect mode of drainage, the extraction depending on the puny action of a variable stream of water (a plain word, which professional brethren will pardon, if occasionally used instead of *liquor*), trickling in its progress from place to place, visiting the inferior side, but not always the interior of the mash, and stealing its way through channels and cavities, between unbroken lumps, and without even entering the compressed masses that imprison large portions of the sweet. To prevent the loss

arising from such irregularities and other occasional accidents, is one of the main objects of the improved apparatus, and particularly of the two peripatetical machines included as parts of this invention.

The properties, uses, and advantages of these machines, upon which the action of the first part of brewing in a great measure depends, are explained herein, each in its chapter; but, prior to this, the preparation of the necessary ingredients, and the rejection of noxious principles, must be considered as a preliminary and indispensable measure.

CHAPTER II.

INGREDIENTS.

EXAMINATION OF CONSTITUENTS—CHEMICAL ELEMENTS—NATURE OF SACCHARUM AND WORT—STARCH, GUM, MUCILAGE, GLUTEN, AND OIL—TUBERS, CORN, AND PULSE—FOOD AND PARTS OF PLANTS—DIVISION OF GLUTEN—APOTHEME AND OTHER MINOR PROPERTIES—USELESSNESS OF PULSE—CHARACTER OF ALBUMEN—WONDERS OF DIASTASE—NECESSITY OF MALTING.

THE Art of Brewing naturally divides itself into two branches or principal departments, which are,—1. Infusion, called *Mashing;* and, 2. Fermentation, more commonly termed *Working.* Preparatory to the first of these is the process of *Malting,* or reducing to a proper consistence; and to the second that of *Cooling,* or the regulation and reduction of heat; and when the liquor has been fully brewed, it must be preserved by *Storing,* which has sometimes its attendant stage of *Racking.* The mode of performing all these several operations in the most efficient manner is the subject at large on which this work is designed to treat, and clearly, if possible, to elucidate. The brewer has to examine the principles upon which these depend, because the virtue of the staple commodity employed in the production of his wort is dependent upon them: he has, therefore, to ask—1st, What is the species of grain or other substance which is best adapted to the production of saccharine and other profitable matter? 2nd, How is the quality of the best samples to be distinguished? 3rd, What are the characteristics of the fittest materials? And, 4th, What is the best mode of preparing them

for the purpose of infusion, decoction, or brewing? The question is not precisely to determine the greatest quantity of absolute alcohol, or intoxicating spirit, (though that is inseparable from the solution,) but how to obtain the best and most of that nutritious constituent of wort, the *saccharine matter*, from which, in combination with other fluids, the alcoholic beverage is produced; though the quantity of alcohol it contains be a fair test of its superiority, and its presence a criterion of its preservative quality.

That all nations, ancient and modern, where liquor extracted from corn without distillation has been known, have produced it from barley, and that a rude mode of previous preparation similar to that which we term malting was known as early as the reign of Cyrus, appears from the authorities named in the preceding chapter; but whether such process is the best that can be followed becomes a question for investigation; because, if we can reject this commodity, and adopt a better, we can claim credit from posterity; and if we see that the old course cannot be altered, we can only do our utmost to amend it, knowing that we have an immovable basis whereon to operate.

This leads to a review of the several kinds of corn, pulse, &c., usually consumed as food. Thomson has compiled from foreign journals perfect analyses of most kinds of grain, &c., ordinarily reared for the market, and has confirmed many of the results by experiments of his own. The following Table, collected from his works, and reduced to the centimal standard, will show, at one view, the constituents of which each is compounded. It may be necessary to premise, that lentiles are the *ervum lens*, vetch, or tare; and that mais is " the seed of the *zea mais*, or Indian corn, a native of America, but now reared in Italy and other southern

countries of Europe. It was cultivated and much used in Peru before the conquest of that country by the Spaniards. They even knew the method of fermenting it, and of producing from it an intoxicating liquid, to which they gave the name of *chicea*." (Thomson's Org. Chem. p. 883.) The gluten of mais is termed *zein* by Professor Gorham, in the Journal of Science, XI. 205. All the rest must be familiar to the common reader. The albumen found by Einhof in barley contained phosphate of lime. Vogel removed the husk from his oats, and afterwards analysed the meal; his sugar contains some "bitter extract," and his albumen is described as "a grey substance *like* albumen." This "bitter extract" resembles the "extract and bitter principle" found by Cadet in coffee, which consists of tannin with oxygen abundantly absorbed, and is more clearly explained under its proper head. The 1 per cent. extractive found by Prout in barley and malt is not a bitter, but is called by him "yellow resin." Convenience does not require separate columns for these.

NATURE OF CONSTITUENTS.	Potatoes.	Rye Meal.	Wheat, French.	Wheat, Odessa	Oats, Ripe.	Rice, Carolina.	Rice, Piedmont.	Mais.	Pea and Pod.	Ripe Peas.	Lentiles.	Field Beans.	Kidney Beans.	Barley, Green.	Barley, Ripe.	Barley Malt.
	SUBSTANCES ANALYSED.															
Saccharum or Sugar ..	....	3.27	4.71	8.02	5.45	0.29	0.05	0.90	4.58	2.11	.. ..	....	....	5.55	5	15
Starch	15.00	61.09	71.13	59.25	38.94	85.07	83 80	88.63	1.38	32.94	32.81	34.17	35.93	14.59	32	56
Gums	....	....	3.31	5.35	1.65	0.71	0.10	2.28	....	....	5.99	4.61	....	....	....	....
Mucilage	4.00	11.09	....	....	....	....	....	....	....	6.49	....	....	19.38	....	4	15
Gluten	....	9.48	10.90	13.27	....	....	....	5.76	1.82	....	....	....	....	1.77	3	1
Bitter and Extractive .	....	....	....	....	....	....	....	1.09	0.65	....	....	3.54	3.41	2.60	1	1
Oil	....	....	....	....	1.32	0.13	0.25	0.32	....	....	....	....	....	....	....	....
Husk	....	6.38	....	1.75	34.00	4.80	4.80	....	10.42	21.88	18.75	10.05	7.50	16.60	....	....
Volatile Matter	....	....	....	....	....	....	....	....	78.13	14.06	3.12	15.62	....	52.12	....	....
Fibre	7.00	....	....	....	....	....	....	0.95	....	...	....	15.88	11.06	....	55	12
Earthy Phosphates	...	....	....	....	....	0.13	0.40	....	0.11	0.28	0.57	0.98	....	....	....	....
Albumen	1.40	3.27	....	....	2.84	....	....	....	0.91	1.72	1.15	0.81	1.36	0.45	....	....
Animo-vegetable	....	....	....	....	....	3.60	3.60	....	....	14.56	37.32	10.86	20.80	....	....	....
Water	71.10	....	9.95	11.00	15.80	5.00	7.00	....	....	....	....	....	....	....	....	....
Loss	1.50	5.42	....	1.36	....	0.27	....	0 07	2.00	5.96	0.29	3.48	0.56	6.32	....	....
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
By whom Analysed.	Einhof ...	Einhof ...	Vauquelin	Vauquelin	Vogel......	Braconnot	Braconnot	Bizio	Einhof ...	Einhof ...	Einhof ...	Einhof ...	Einhof ...	Einhof ...	Prout......	Prout......

To readers ignorant of chemistry, it may be useful to premise that this Table exhibits, as nearly as analysis has approximated, and with sufficient accuracy for the present investigation of constituents, all those *proximate principles* of the substances under consideration, which in chemical language are termed their *primary compounds*, as saccharum, starch, &c., each of which has its own function in forming and supporting the structure of the seed, root, or other body referred to; and each primary compound is resoluble into the *ultimate elements* denominated *not* "fire, air, earth, and water," as the four elements of ancient philosophy, but

(O.) *Oxygen:* the fiery or acid basis (from **Οξυς** [Oxys], sharp, acid, nimble, acute, swift; and **Γενναω** [Gennao], to generate or produce).

(C.) *Carbon:* the earthy or coaly (from the Latin *carbo*, a burning or common coal; but the Greek is **Ανθραξ** [Anthrax]).

(H.) *Hydrogen:* the water or humid (from **Ὑδωρ** [Hydor], water; and the same generative term as before); and

(Az.) *Nitrogen:* the airy or nitrous (from **Νιτρον** [Nitron], nitre, *saltpetre* or petrified salt; and as before). This element is also called *Azote*, from **Αζω** [Azo], to be dry; to suck in.

These elements, by combining together in an endless variety of ways, form all the complicated substances discoverable in the universe, be they animal, vegetable, mineral, or gaseous; and, according to certain philosophers, the primary compounds most important to the vegetable economy are *sugar*, *gluten*, *farina*, *mucilage*, and *oil*, each possessing very different properties from the rest, as regards the production of nutriment. The Table extends to other principles, equally proximate as constituents of the vegetable substances examined; and

we have now to show how far they individually affect the constitution of wort by sharing in its composition; the final object being the discovery of the proportion necessary to sustain the ultimate elements on the most advantageous terms; since on them, however blended in the compounds, the constitution radically depends. The Saxons, as appears above, gave to this extract the name of wort; first, because it requires *working* in the mash; and, secondly, because it *works* itself into spirituosity by fermentation; and, if we are really good brewers, we shall pass it safely through both processes, leaving it with characteristic virtue at subsequent command.

Thomson's definition of the wort derived from barley-malt is, that it consists in the mealy parts of the grist being held in solution by the water employed: so it does; but he also says, that it *appears* to consist of *four* substances so held, which he calls *saccharine juice*, *starch*, *mucilage*, and *gluten*, combined with *tannin;* and of these, the brewer knows that in good worts saccharum is the principal constituent that demands his care to preserve it. Experience soon teaches him to know it by the sweet odour of his wort, by its luscious taste, by the brown or golden colour which it imparts, and, where his process is properly conducted, by its perfect transparency; but, after all, what is it? How and where obtained? How best preserved? How far, and in what manner, does it combine with the other ingredients which assist in the solution, transmutation, and purification of the beverage?

1. Saccharum.—This substance, called by Paul Egineta *sal indicus*, or Indian salt, being, as he says, like common salt in colour and concreteness, but like honey in taste and flavour, appears to be similar to the juice with which the Armenians, as above noticed, impregnated

their malt-liquor to strengthen it; and to that which Theophrastus, who died B.C. 288, described as *the other honey which is in the reed;* though, with respect to colour, the saccharum from British malt is brown, darkening gradually when it is heated, becoming brittle and glazed when dried at 160°, and if raised to 180°, and occasionally damped, turning nearly black, losing its sweet taste, and acquiring a sharp disagreeable one, and completely charring at 200° or thereabouts: at least, somewhere below the boiling point, or 212°. It was little known in Europe before the Christian era; but was noticed about the middle of the first century by Dioscorides the physician and Pliny the naturalist; the former of whom informs us, that *saccharum is a certain kind of concrete honey from India and Arabia Felix, found in reeds, like salt in its concretion, and is broken like salt when subjected to the teeth;* and the latter says, that *Arabia brings saccharum, but India is more praised;* it is *honey collected in reeds, clear like gum, fragile to the teeth, and is of very extensive use in medicine, as much in size as that of a filbert-nut.* Lucan, a contemporary poet, who died in 65, has the following verse in praise of it:

"Quique *bibunt* tenerâ dulces ab arundine succos."

That is, Whoever *drink* the sweet juice from the tender reed. But it stands as a confirmed opinion, that these Arabians and Indians within the Ganges, were not growers, but mere *mercatores* trading with the Romans; and that they were supplied with this, as with other precious spices, by the exporters from Bengal and Siam, who had first brought the plant from China. From the medicinal properties of this "*gummi modò candidum*" exuberance, or Eastern *sugar-candy*, and the patronage bestowed on it by the faculty of those days, Piso relates that it became scarce and high-priced, which induced

those Arabs and Inner Indians, from the description given of its growth by those with whom they traded, to search for it at home; and they had the good luck, not many centuries back, to pick up the indigenous *Mambu*, from the knots of which, after some four years' growth, a *white*, spongy, light juice exuded, in which they found a sweet taste so like to that of the saccharum, that they soon became able to compete with the foreigners in their own markets, by introducing it as what they called their *Sacchar Mambu* or *Tabaxir*; and the Arabians also found a species of dog's-bane, or Apocin, which they called *Alhassar* or *Alhuzzar*, from which they abstracted a third kind of saccharum, which they titled *Alhasser Zuccar*, whence, by corruption, our word *Sugar*. Thus were three species known, independently of that obtained from malt, which three are severally called by Avicennes the *Zuccar arundineum*, or Indian salt; the *Zuccar Mambu*, or Persian *Tabaxir*, and the Arabian *Zucchar Alhasser*.

Hence sugar and saccharum are synonymous terms, applied to almost equivalent matter, except that one is fluid and the other dry and crystal, and are *food* and medicine for the nourishment of man; and two remarkable coincidences may be observed in relation to them: one is, that the sugar-cane contains about equal portions of sugar and molasses, while the barleycorns, when malted, yield like quantities of sugar and mucilage; and the other is, that just when malting began to be practised as an English trade, the inhabitants of southern Europe turned their attention to the cane; for in 1250, Marco Paulo, a nobleman of Venice, travelled to Bengal in search of it, and planted it in Arabia, whence it passed into Nubia, Egypt, and Ethiopia, and subsequently into Morocco, Sicily, and the Atlantic islands, where it was fostered, till, in 1520, St. Thomas alone

had sixty manufactories, producing annually 150,000 arobes, each thirty-one avoirdupois pounds, or nearly 2076 tons. Liquid or uncrystallisable sugar was first pointed out in Spain by Proust, who has shown its habitation in a variety of fruits and vegetable juices. It was found in carrots by Margraff, and is a principle in liquorice, distinguished from every other species of sugar by being incapable of forming crystals like those of the sugar of commerce, so that it can only appear in a liquid state. According to experiments made by the Duc de Bullion, the juice of grapes yielded from 30 to 40 *per cent.* of this saccharum; and Proust asserts, on the strength of his experiments, that the raw sugar from grapes, when sufficiently diluted with water, ferments, and is converted into wine. Now it appears from the above Table, that of the substances investigated, none but corn-seeds and peas contain this saccharine matter without conversion; but that mais has more than 88 *per cent.* of starch and hordein, which latter is a distinct farinaceous substance, similar to one whose particular province is barley; and that rice has in it a small portion of an ingredient resembling it; and again, that the sugar is decreased by the ripening of the seeds, while their starch is very materially enlarged; whereas the malting of barley trebles its sugar, and almost doubles its starch, which is vastly important; for as saccharum is the first essential of wort, its conversion and preservation are of paramount consideration. Sugars differ in constitution; for the ultimate elements of cane sugar are O. 50·63, C. 42·47, and H. 6·9, according to Gay Lussac and Thenard; but starch sugar is O. 55·87, C. 37·29, and H. 6·84, as given by Saussure; and sugar of malt by Proust is O. 56·71, C. 36·2, H. 7·09.

2. Starch.—The presence of this substance, appa-

rently the most abundant constituent of ripe grain, is readily detected by iodine, which produces a blue colour; or by dropping an infusion of nutgalls into the wort, when a precipitate will appear, which, at the heat of 120°, will chiefly re-dissolve, leaving only a little of the combined gluten and tannin unaffected. Starch was well known to the ancients, as Pliny informs us in the seventh chapter of his eighteenth book, that the inhabitants of Chio first discovered the mode of procuring it. Saussure ascertained that 100 parts of starch, when converted into sugar, became 110·14 parts; and concluded, hence, that starch-sugar was a mere compound of starch and water in the solid state; and Kirchoff, a Russian chemist, found that starch might be converted into a juice possessing precisely the properties of sugar of grapes, by mixing it with water four times its weight, and sulphuric-acid about a hundredth part; after which he boiled the mixture thirty-six hours, supplying fresh water as fast as the old evaporated. It has also been found that sugar so obtained melts at the temperature of boiling water, and spontaneously undergoes the vinous fermentation when dissolved in water and sufficiently diluted. Thus we see the perfect nature and properties of saccharine matter, and the way in which it can be produced from starch, which is a matter of first-rate consequence to the brewer, seeing what a quantity is contained in ripe grain, and how it is increased by malting.

It seems from the discoveries of Raspail and Guerin Varry, chemists of great eminence, that when starch is examined under a microscope, it is found to consist in a number of rounded grains, of somewhat variable shape; and that these lodge in cells in the particular plant that produces them, and that their magnitude enlarges as

the plant grows and ripens, which circumstance accounts for their paucity in green corn, as shown by our Table.

Potatoes.—These contain 15 *per cent.* of starch, 7 of fibre partaking of its nature, and 4 of mucilage, with a superabundance of water, and rather less than 1½ of *albumen*,—a substance noticed near the end of this chapter. The fæcula or starch of the potato, differently as the two terms are commonly considered, is no other than a *gum*, divided into minute portions, each of which is a globule inclosed in a shell of tissue; and chemists have discovered that the latter only is coloured blue by iodine. Add an alkali, and it becomes soluble; add an acid, and it converts it into sugar like that of grapes. Gum is considered to be the nutrient principle of vegetation, disposed freely among the constituents of plants, and constantly in action; but starch is stored up in such a manner that the water of vegetation does not easily solve it; and this, as well observed by Du Candolle, agrees very well with the office assigned to it in the vegetable economy, of forming a reservoir of nutritious matter to be consumed, at particular periods, in supporting the plant. In corn and buckwheat the storehouse is with the albumen of the seed, but in most other plants it is elsewhere; as in the potato, for instance, it descends into the root as the plant becomes mature. At page 100 of the "Society's Treatise on Botany" (Nat. Phil., vol. iv.), the editor observes, that in all these cases, the starch is either capable of supplying food to the young plant, or it may be supposed to be provided for the sustenance of man; but that the former is the more immediate destination, is probable from its continuing to increase during the latter part of the year, when the plant is preparing a fresh supply,

reaching its *maximum* when it has ceased to grow, remaining stationary in winter, and rapidly diminishing with the growth of the young shoots in spring. This is exemplified in a French work on agriculture, which shows that 100 lbs. of potatoes contained the following quantities of starch at different stages:—

	lbs.		lbs.		lbs.
In August ..	12	In October	17	In April	13¾
In September	14½	In March	17	In May	10

Potatoes, in their raw state, do not contain any gluten; at least, Proust could not find it, nor does our compiled analysis show that Einhof was more successful; and moreover, like rice, which baffled the efforts of Vauquelin, they are also destitute of saccharine matter; and Liebig observes, that if they grow where they are not supplied with earth, as in a cellar for example, a true alkali called solanin, of very poisonous nature, is engendered in the sprouts that shoot towards the light. Yet potatoes will convert into a species of malt, and may be deprived of their generative function; since it is well known that whole cargoes brought from Ireland, and overheated in the passage, have entirely failed as seed. And they possess other principles in common with grain; for Thomson, after reciting Einhof's experiments on potato starch, in the residuum of which he discovered albumen and mucilage, says that the juice which may be separated from them when boiled is sweet-tasted; consequently, it is saccharific. He tells us that the meal is insoluble in boiling water, though potato-starch forms a transparent solution with it; and accounts for the difference by supposing, quite rationally, that the albumen, fibrous matter, and starch, combine by boiling, and form an insoluble compound.

The direct conclusion, therefore, is, that though pota-

toes differ essentially from wheat and barley in containing no gluten, yet the detection of *mucous sugar* and gum by Peschier, which sugar is the basis of wort, demonstrates that potatoes thus prepared are capable of undergoing the vinous fermentation.

Sir Humphrey Davy argues that an acre of potatoes will produce 4031 lbs. of starch, gluten, and sugar, which will yield 2200 lbs. of brewing extract; while he believes that wheat contains no more than 1289, barley than 1242, nor oats than 990 lbs. of the compound, respectively yielding but 900 lbs., 750 lbs., and 629 lbs. of the extract; and as starch is chemically allowed to be the parent of sugar, and as the fæcula of potato is readily converted into starch, one author strongly recommends it to the brewer's attention, and prefers the farina and sugar of potato to the ordinary kind for all culinary purposes, except that of making bread, the lightness of which he ascribes to tenacity in the gluten of wheat; and from the feature of his treatise, it seems that the introduction of potato brewing, and potato conversion at large, has been one of the chief objects of his publication. It is certain that much contraband sugar is made from the potato-root, and from beet, as some extensive seizures have, within a few years back, been made by our excise; and though the analysis of the root does not show that it is glutinous, but starchy and mucilaginous, still the sugar, which the starch is made to yield, may be converted into an alcoholic beverage by solution and the application of barm, containing albuminous gluten as an ingredient. This beverage may not be imperishable, neither has the art of man provided such; and then the author before us truly says, that unfortunately, through the stringency of our excise laws, the purposes to which such an extract is applicable are in a great measure prohibited;

and this settles the brewer's doubts, if he has any, as far as potato beverage can concern him.

But though the matter called *solanin*, *solanina*, or essence of night-shade, of which genus the potato is the species *tuberosa*, has been shown to be poisonous; and though Dr. Thomson advises extreme caution in the use of the shoots after germination has begun, yet with fæcula, more particularly if in good season and keeping, it is otherwise; for Ham's potato sugar, which is quite hard and beautifully white, is preferred to the best refined sugars of commerce by makers of wine who have tried it in private houses, from the accredited assertion that it does not readily become acid, owing, no doubt, to the absence of gluten within it, which, if resident, would attract oxygen and present it to the alcohol, converting it into acetic acid.

He tells us that the whole French nation is alive to the superiority of potato sugar; but, admitting the impolicy of parliamentary dictation to the manufacturer of any staple article of necessary consumption, inasmuch as it manacles ingenuity, menaces industry, and prohibits fair and free competition, thereby upholding monopoly, the retarder of knowledge, and the crippler of economy; still, inequitable as setting off restriction against principle may be, his mode of handling this tuber is objectionable from the tenor of his own language, where he informs us that the brewers and distillers of France sweeten their flour by a process which it would be foreign to his purpose to describe. Why so, if it works a beneficial conversion? The more we learn, the wiser we ought to become: but another block obstructs our way; for at present it is, as he says of oats, "Too inferior to bear a duty of 2*s.* 6*d.* *per* bushel," even in fæcula; and to that decision we are legally bound to submit, whether we give

the experiment a private trial or not, so long as the restrictive duty remains upon the produce of the soil to damp the energies of enterprise. The duty is 2*s*. 8½*d*.

Saussure, Gay Lussac, and analysts of a later date, give the elements of several kinds of starch thus:—

Potato:	O. 49·076,	C. 44·25,	H. 6·674.	—100.
Wheat:	O. 49·04,	C. 44·26,	H. 6·70.	—100.
Rye:	O. 49·20,	C. 44·16,	H. 6·64.	—100.

GUM is analogous to starch, as albumen is to gluten; it is the *amidin* or liquid yolk which fills the vesicular pustules already noticed, which latter chemists distinguish by the term *amylin*. In an analysis of the starch of potato by Guerin Varry, he gives the proportion thus:—Amidin, 38·13; amylin, 59·75; and an external tegumentary amylin, 2·12 *per cent*. Gum itself is in specific gravity from 1310 to 1430, and has no smell. Proust's analysis of wheat starch, after 20 hours' exposure at the boiling heat, and 6 more at above 300°, became O. 49·78, C. 44, and H. 6·22 *per cent*., differing but little from the above.

According to our Table, gum abides most particularly in coffee; to some extent in wheat, beans, and lentiles; more sparingly in mais and oats, and triflingly in rice; but *is not found in barley or malt*, rye, peas, kidney beans, or potatoes; but as potatoes and barley-meal have been found to abound in starch, where it originates, the gum generally collected in this Table must differ from the amidin or egg of starch, in some particulars. Thomson affirms that alcohol separates starch in part from its decoction, but that gum is insoluble in alcohol; and that if alcohol be poured into *mucilage*, the gum, from the greater affinity of water to alcohol than to it, immediately precipitates in white, soft, opaque flakes, which will not solve in ether or in oils. But

gums are various, according to the substances that produce them ; and different kinds are obtained by different and even contrary processes, and we need not hunt for gum arabic, gum senegal, or gum guiacum, in proof of it ; besides which, some chemists seem to stumble between gum and mucilage, which are not by any means the same ; and it will be found well for the brewer not to confound the distinction : his gum is the *amidin* of starch, before noticed.

Starch gum and sugar readily unite when both are dissolved in water, and by gentle evaporation a solid substance is obtained, which, like the Indian salt of the ancients, is uncrystallisable and perfectly transparent. This gum is nutritious, though alone it cannot support life, and in its composition it approximates, as well may be imagined, to that of starch itself, its elements being composed of O.50·84, C.42·23, and H.6·93, according to Gay Lussac and Thenard ; of O.51·2, C.42·2, H.6·6, according to Goebel ; and of O.51·31, C.41·91, and H.6·78, according to Berzelius ; which trifling difference might easily arise from diversity in the quality of the starch, and they are almost identical with the results severally obtained by the same philosophers from their experiments on raw sugar; and as sugar contains neither earth nor alkali, no more does this kind of gum.

An article called British gum is thus described in the Magazine of Science, vol. i. p. 32 :—" A gummy substance, obtained by heating starch until it obtains a slightly brown colour, which it will do at a temperature of between 600° and 700°. It is soluble in boiling water, but not in cold ; and if a few drops of tincture of iodine be added to the solution when cold, a purple colour is produced, and not a blue, which the unburnt starch would have produced ; showing that, during the roasting, a chemical change has been effected. A

gummy substance analogous to this is obtained by the addition of strong sulphuric acid to paper or woody fibre, such as sawdust; and then saturating the acid with chalk, this gum is left." Similar to this obdurate substance, therefore, must be the gum of roasted coffee or of porter-malt, which is rendered strongly adhesive by heat, but is deprived of its saccharine consistency and its liquescency. Starch, therefore, is clearly convertible either into liquid saccharum of a nourishing nature, or will set into an inconvertible and tenacious gum; and it is the brewer's province to promote the one, and to prevent the other.

3. Mucilage is that which, according to Thomson, "precipitates in flakes when the wort is dropped into alcohol," and which he observes to be more considerable in the last-drawn worts than in the earlier and stronger. Hermbstadt distinguishes mucilage from gum thus: the former is opaque, the latter transparent and glutinous; the former does not feel glutinous, but slippery, and cannot be drawn out into threads, whereas the solution of gum can be so drawn out. The following has been given as a mode of separating the one from the other: Reduce the mixture to a dry mass; dissolve it in the smallest quantity of water in which it can be done; drop into the solution, time after time, diluted sulphuric acid: this will coagulate the mucilage, but the gum will remain dissolved; and when the coagulation has ceased, if the mixture remain awhile at rest, the mucilage will precipitate and become a jelly. Mucilage is therefore a substance wholly distinct from gum, rather than the product of some new combination and transition, being co-existent with it; and Einhof must have been conscious of the dissimilarity when he found the one in field beans and vetches, and the other in ripe rye and barley, peas, kidney beans, and potatoes; and we shall

presently see that it has not the same function, but can occupy a separate habitude. Indeed, it is thus otherwise described:—" Next to gluten, in the property of affording nourishment, is *farina*. This is found most copiously in wheat, and it forms a considerable portion of the nutritive parts of various kinds of pulse and tubers. Most fruits contain a basis of mucilage or farina, which is combined with sugar or with oil. Sugar is among the most highly nutritive of all the vegetable products, and oil seems capable of being converted almost wholly into nutrient matter." (Treatise on Animal Physiology, Nat. Phil. p. 47.) Mucilage is therefore not a food within itself, possessed of intrinsic virtues, but merely holds the nutrimental part of food consistently together, and is susceptible of disengagement by common solvent means; resembling in these particulars the *amylin* or *shell* of starch. Hence we must regard with caution any expressions which treat mucilage and gum synonymously. Thomson says that there are many kinds of seeds, as linseed, for instance, which, on being macerated with water, make it become thick and adhesive, *converting it* into what is called mucilage; and that the solution of *arabin*, the principal constituent of *gum* arabic, used by calico printers to thicken their colours and mordants, and thereby to prevent their running, " is known by the name of *mucilage*." We might hence conclude that mucilage was the produce of a secondary admixture or transition from the state of starch; but the fact is, that these adhesive solutions contain gum as well as slime, and this is the admixture of which kidney-beans contain more than four-times as much as barley-meal, and of which the same chemist says that water dissolves *gum* in large quantities which are thick and adhesive; the solution, when spread thin, having the appearance

of varnish, and readily attracting moisture and becoming glutinous; for though he says that it is "known by the name of mucilage," he admits that water washes it away; and that, when mucilage is evaporated from it, the gum is obtained unaltered. In another sentence he terms it a *mucilaginous* solution, speaks of its great non-liability to decompose, as it will keep for years without putrefying, but says that "*at last* the odour of acetic acid becomes perceptible in it."

No doubt the elements vary in mucilage as in other substances, according to the nature of the substance composing its basis. Marcet analyses mucilage at O. 53·09, C. 41·4, H. 5·51, and Guerin Varry gives for the mucilage of linseed, O. 52·78, C. 34·30, H. 5·65, Az. 7·27; but it may be presumed that the quantity of nitrogen which thus distinguishes mucilage from sugar, starch, or gum, is an accession chiefly at the expense of the carbon, which, though dependent on the character of the seed examined, pronounces it at once a separate substance.

4. Gluten.—Thomson asserts that the other ingredient in wort is the insoluble part of the precipitate thrown down by the gall test, and is a combination of *gluten* and *tannin*, and very inconsiderable in quantity. He pronounces gluten one of the most useful vegetable principles, and says that it is an essential constituent in wheat, because it renders the flour fit for forming bread. It is, in fact, a strong stimulant, whereas mucilage is languid and passive; and this stimulative power of gluten is particularly useful to the brewer in producing alcohol, by its excitement in the act of fermentation. It is a substance which he studies to eject, though he must first avail himself of its services. Beccaria, an Italian philosopher, who undertook to analyse wheat-flour in 1742, first discovered this substance thereby, and found it to be grey, tenacious, elastic, and

ductile, capable of being stretched out to many times its natural length, like Hermbstadt's gum, to which it is allied. We see by our Table that it is doubled by the ripening of barley from a certain stage; that it abounds in wheat and rye, and that mais is tolerably prolific of a matter so essential, the value and use of which may be appreciated from the definitions every where given of it. The writer on Animal Physiology above quoted, speaking of vegetable materials, defines it to be the most nutritious of them all; its elements the most nearly resembling those of animal matter, and that it contains nitrogen in considerable quantity: an element which is absent from almost all the vegetable products; and observes, that it is found in the greatest proportion in wheat, which fact the Table tends to substantiate.

Hence, though vegetable gluten has been known now a full century, its true properties and principles have been but little studied as such; for if they had, G. Varry would have found less nitrogen in linseed mucilage. Dr. Liebig, in his "Chemistry in its application to Agriculture and Physiology," (chap. v. p. 70,) has this sensible passage: "We cannot suppose that a plant could attain maturity, even in the richest vegetable mould, without the presence of matter containing nitrogen, since we know that nitrogen exists in every part of the vegetable structure. The first and most important question to be solved, therefore, is, how and in what form does nature furnish nitrogen to vegetable albumen, and gluten to fruits and seeds?" This subject he proceeds to investigate at considerable length, and concludes that they are imbibed from the atmosphere, thus supporting Schrader's hypothesis on the natural food of plants. Thomson pronounces gluten a common ingredient in the structure of vegetables, but, as he says of albumen also, extremely various in quantity and appear-

ance; and, accordingly, he thinks of the substances composing rye, that they must vary exceedingly in proportion, according to soil, climate, and age; let us, therefore, proceed to examine that seed in connexion with gluten.

Rye.—The gluten of rye and that of wheat differ, as most other things do, in many particulars, and that of barley from either of them. Wheat gluten is more tenacious than that of rye, and not so soluble. Rye gluten and water form a mass, which contracts by boiling. Einhof fermented it, and found that it emitted a strong smell of nitric acid, but he did not perceive this scent arise from the gluten of wheat. The saccharum of rye, when freed from its attendant gluten by dilution, digestion, and evaporation, though sweet, has a harsh taste, and has become soluble in water, alcohol, or ether, and is propense to turn immediately sour; which harshness, added to the reality that the meal contains 11 *per cent.* in mucilage, and only 3¼ of this inferior saccharum, added to the tediousness of obtaining the latter, and the certainty that rye-bread, however sweet, speedily acetefies, quite unfits this species of corn for the brewer's use.

Rye, having gluten for its support, would have less disadvantage, notwithstanding, if it could be properly malted; but to this the thinness and weakness of its husk constitute an insuperable objection; for as soon as its farina is made to expand, through the absorption of moisture in the steep, and germination begins to ensue, the cuticle breaks asunder, and the rising plumula, having no stay to control it, creeps through the fracture and grows externally, which is commonly termed "malting the wrong way;" hence, being unprotected, it is easily broken off in turning, by which breach not only is its further growth prevented, but the mutilated grain

becomes mouldy and putrid, as we shall find to be the case with over-thrashed barley. Rye is also subject to a terrible disease called the *ergot*, or *horns*, in which state it is called *secale cornutum*, and, if taken into the stomach, will produce tetanus, gangrene, and death; but of course the brewer would not buy it in that state.

Wheat.—Let us now treat of gluten in its relationship to the *triticum hibernum*, or winter-wheat, described by chemists as by far the most nutritious kind of corn; for here, again, our interest may be affected to a great extent. Thomson found it composed chiefly of starch and gluten, of which starch was the more prominent, with small portions of saccharum and bitter, to which Fourcroy and Vauquelin add mucilage. The specimen from Odessa in the Table above, is taken at the average between hard and soft grain; but the analysis of the hard is, starch 56·5, gluten 14·55, sugar 8·48, gum 4·90, bran 2·30, water 12·00, loss 1·27; total, 100. But the flour used by Paris bakers, as analysed by Vauquelin, gave starch 72·8, gluten 10·2, sugar 4·2, gum 2·8, water 10; total, 100: an inferior kind yielding less starch and more gum and water, with 2 *per cent.* of bran; and it must be noted, that here, as in the Table above, the gluten is not purely such, but "a mixture of gluten and albumen;" and the fact is, that chemists now divide gluten into four distinct substances: *albumen*, *mucin*, *emulsin*, and *glutin*. The elements of wheat-gluten are thus given by Jones: O. (with sulphates and phosphates) 23·56, C. 53·83, H. 7·02, N. (az.) 15·59.

Nine bushels of wheat, ten of rye, and nineteen of oats, are respectively allowed to be equal to thirteen of barley, and to produce equal quantities of beer of the same strength; if, therefore, they were equally eligible and available, their several market prices would deter-

mine the relative advantage or disadvantage of brewing from each, the disproportion being chiefly consequent upon the bulkiness and compactness of the kernels of the more productive sorts, and on the thinness of their cuticular covering. The author has behind him the experience of the seasons succeeding the harvests of 1834 and 1835, when wheat sold at 36*s.* to 40*s.* *per* quarter, and barley, being scarce, was considerably higher. Large quantities of the former were then malted, and made good ale, when properly attenuated, if the wheat had been very carefully treated in the manufacture; but it is best to malt it mixed with barley, the spires of which will protect it, and regulate its temperature; for as its plumula bursts forth through its tender coat of bran more abruptly than even in rye, it is in great danger of decapitation if rudely handled; and it requires to be mixed in the mash with some huskier or chaffier substance, because it contains so much farina in proportion to its cuticle, that it would otherwise set into a paste, from which the extract could not be obtained without difficulty and danger. Nothing is so good to mix with it as barley-malt, well crushed; and it is better not to crush the wheaten malt too fine, for it contains too much starch, and too much gluten with it, to suit the purpose of solution; and hence the facility with which it runs into acetous fermentation, and the reason at once why the produce will not keep so well as the wort from ordinary malt; though the author ventures to assure himself, that by the new process of conversion and extraction in the mash-tun, further aided by the improved mode of fermentation which he prescribes, all the superlative gluten would be removed, much of the starch would transmute into saccharum, and consequent advantage could be taken of

the superiority of wheat over barley under such favourable circumstances of price.

5. Bitter and Extractive.—When Dr. Thomson found his gluten combined with tannin, he must have experimented upon the wort of particularly high-dried malt, as we find no such principle existing among our tabular constituents ; but he has discovered, that when coffee is *roasted*, tannin is formed within it by the action of heat ; and we may suppose the same of roasted malt or corn. Paissè, however, who has analysed that berry with great care, says it is not tannin, but a peculiar acid, called by Chenevix *caffeic-acid*, and by Cadet *caffein*,—which, they say, though it reddens vegetable blues, is not entitled to be called an acid : it is a *colouring matter*, created by the action of heat. The bitter principle which gives to certain substances a dye, and in some instances an offensive taste, may, for the sake of chemical euphony, be termed *amarin ;* but it evidently differs in quality and character, according to the nature of its maternal plant, and sometimes is named accordingly ; as *quassite*, from quassia ; *brionite*, from white briony, by country people called mandrake ; *berberite*, from barberry ; *lupinite*, from lupines ; and *lupuline*, from hops, though a very different species is extracted from wolf's-bane. If each plant had not its peculiarity, nature would have no need for distribution of genera into species, nor would language have need for a corresponding adaptation of epithets ; and the words here applied to their extractive principles are a mere Latinising of the essence to the botanical classification of the substance. They are of no use to the brewer, but, like the bundle of evils in Pandora's box, they have each one single item of albumen lying at the bottom.

Similar to amarin is extractive, which is defined to

be a principle existing in bark, with a strong taste, containing an acid liquid, and being insoluble either in alcohol or in ether, but soluble in alcohol when containing water, and then it will also solve by evaporation; but the term seems to have been generally applied to the remnant of a solution when every thing was gone which distillation or evaporation could carry off. Fourcroy and Vauquelin describe it as a substance at first soluble in water, but insoluble after exposure to the air, through having absorbed oxygen there; but Saussure controverts their argument, and says that instead of imbibing oxygen, it gives out hydrogen to it, converting it into water. Berzelius is of the same opinion, and distinguishes it as a brown substance from other *extracts* used among apothecaries, by the term *apotheme.* Its general character is, that it solves with difficulty, and imparts deep coloration to the water or alcohol in which it separates. It seems from our Table to be contained in peas, beans, and mais, but not in any other ripe corn, and therefore does not further concern the present inquiry, as we shall find that these are not brewing materials.

6. Oil is everywhere a sign of fatness, as mucilage is of exhaustion. Thomson's description of vegetable oils is very clear and comprehensive, where he divides them into *fixed* and *volatile.* Fixed oil, he says, is found nowhere but in the seeds, and is almost entirely confined to such as have two cotyledons, as linseed, almonds, beech-nut, poppy, rape, &c., and the volatile in every part of the plant except the cotyledons of the seeds, where they *never* occur.

Now cotyledon is a Greek term, from κοτυλη, a *cave* or *hollow*, particularly applied in the parent language to the hip-joint, but botanically to that part of a seed in

which are posited the organs that renew the species. In native English, the interior of this cotyledon is called a *kernel*, which latter word is no more than a diminutive of *corn*, though more commonly applied to nuts and the like, but by maltsters very properly to barley and malt. Every *graminous* plant (from *gramen*, grass or grain), is *mono*-cotyledonous, or has its kernel in *one* piece; whereas pulse, such as peas, beans, or vetches, are *bi*-cotyledons, or are split into two parts; whence it would appear that the fixed "fat" oils found by Braconnot in rice, by Bizio in mais, and by Vogel in oats, were exceptions to natural principle, as are similar oils extracted from rape, mustard, and almonds; but Fourcroy and Vauquelin have found such an oil also in barley, which they say is like coagulated olive-oil, but darker, resembling butter, burning like lamp-oil, and will form soap when combined with an alkali. (Mus. de Hist. Nat. 38, p. 8.) Thomson remarks, that this barley-oil has escaped Einhof's notice, though he has obtained it in his own experiments, by the same process as the French chemists. This subject, and that of resin, will be found discussed more fully in the next chapter, under the head, "Constitution of Malt."

7. Husk.—Having now proceeded to observe upon the most important primary compounds, as enumerated after the Table, we see that in the collection of seeds, some few constituents remain to be disposed of: these are, husk or fibre, volatile and fibrous matter, phosphates, animo-vegetable matter, and albumen. The husk in ripe peas exceeds one-fifth of the whole bulk, and is wholly unprofitable; but in the ripening of barley it is reduced from 16½ to 6½ *per cent.*, the analyst qualifying it by observing that it is not only husk, but contains starch and gluten. But the most prominent seed

in the article of husk, as it is also of fat oil, is that considerable production and "staff of life" of our more northern and hilly provinces:

Oats.—The husk of this seed, amounting to one-third of its whole constituency, is known to be a thick, glossy, outward shell, as hard and compact as reeds, or the strongest wheat-straw, and inclosing an inner membrane or parenchyma of great nutritious virtue, which again covers the cotyledon. The quantity of starch is still more considerable than the husk, but Thomson admits the difficulty of freeing this starch from "another substance with which it is united," without acquainting us with the nature of that substance; so that its properties can only be inferred by consulting the Table; though in his account of Scotch *sowans* or *flummery*, he gives an interesting account of the parenchyma and its virtue, but, unfortunately, like rye, it is apt to "become sour." The interposition of this middle film, the smallness of the kernel compared with the husk, and the tardiness which its obduracy inflicts upon the germ, combine to render the malting of the oat a disadvantageous speculation, particularly when the *duty* is considered, whatever may be the value of the interior substance. It is true that in the North it is usually cultivated for human food; but as a malt it is so proverbial, that a person of inert or slothful habits is said to be "as dree as haver maut." Unleavened oat-bread, however, if stored dry, will preserve unimpaired for years; and the saccharific character of the plant is demonstrable in the sweetness and feeding quality of the cake, the richness of its parenchyma, and the avidity with which cattle feed upon the straw.

Rice.—Vauquelin, who published an analysis of this grain, which may be seen in the 12th book of the Annals of Philosophy, could not find any saccharine

matter in it, but "a little liquid gum and some sulphur" instead; and it neither contains gluten nor albumen; therefore it is not a proper brewing ingredient, but is nearly the same as sago, which is classed by chemists as a "pure starch," and sets into a jelly at a low temperature; and, instead of yielding a limpid fluid, absorbs the liquids presented to it, and stiffens with them into a solid mass, which hardens as it cools.

Mais.—Respecting this foreign production, a few words may serve. An analysis of the dried grain is given by Gorham thus: starch 84·6; zein or gluten 3·3; albumen, distinct from gluten, 2·7; gum 1·9; sugar 1·6; unaccounted for 5·9. Here may be all the requisites for brewing the *chicea* of the Peruvians, but none of the extractive named by Bizio, which drew into threads while warm, but became brittle when cool, with amaradulcet taste and the smell of honey; whence it seems that analysts differ in their views of the finer matters. The zein of Gorham did not afford any nitrogen, and was therefore inert; but the albumen was more considerable than we find it in any other corn except rye. Bizio also gives 1 *per cent.* not of fibre, but *zimome* or *amidin*, besides the undissolved starch; whence it appears that he took his analysis when the starch had begun to burst, and consequently, as shall be shown, when diastase was at work. This zein is yellow, viscous, and ductile, like the resin of barley, and is also without taste or smell, so that it more nearly resembles gum; but it is useless to us, and the quantity of starch in this seed is prodigious, and may lie on the same shelf with rice.

8. Volatile Matter, from *volo*, to fly, is that which is easily carried away by evaporation or otherwise. This matter appears to be five times as plentiful in the unripe plant as in the seed, which is shown in the

instances of barley and peas, amounting in the early stage of the former to more than half, and in the latter to four-fifths of the whole, but reduces by ripening to 10 *per cent.* in the pea. Barley has, therefore, a preferable substantiality in this respect, as well as in glutinous food, which is doubled as it becomes mature, whereas in the growth of the pea it entirely wastes away; and again, the saccharine matter, which is not materially diminished by the maturing of the grain, is reduced one-half in the pulse by the same process, all which things militate against the pulse and for the grain; and though the saccharum or immature juice of the barley is reduced in quantity, or rather is gone, it is replaced by a superior quality. Einhof, as it will be seen, found that the pod of the pea contained more volatile matter and starch, in proportion to its bulk, than when pod and pea were taken together, but less gluten and vegetable fibre, and only half the albumen.

Peas.—Einhof also noticed, that the sweet juice of young peas might be obtained by slight pressure; that when a quantity was exposed to the air, a thin skin gathered upon the surface, and afterwards fell to the bottom in white flakes; and that it gradually and spontaneously fermented and became sour; the residue, composed of the coats of the peas, and a white, fibrous, and tasteless matter, dissolved in hot water like starch, resembling it in some measure, but agreeing in its properties with the fibrous matter of potatoes. None of these phenomena occurred in the treatment of the ripened pulse or grain, though the water in which the green barley had been macerated deposited some flakes of albumen when boiled. In all these respects, therefore, barley is superior to peas; and though many, not excepting persons connected with the excise, harbour an idea that a few peas thrown into a couch of malting-

barley will vegetate with it, and improve the brilliancy of the article made from it,—the idea of the apple-pie made all of quinces will show its erroneousness, as a brewing of unadulterated pea-malt would at once demonstrate; for it would, in the first instance, have to pay one-third more duty, and ultimately not more than five *per cent.* of the whole pea would incorporate with the wort. The experiment of sprinkling peas upon the couch is not usually done to a greater amount than one *per cent.;* and the idea that one-twentieth of that, or a two-thousandth in the magnitude of the mass, could have any sensible apparent effect, either clarifically or aromatically, is truly preposterous, unless it were all diastase, or analogous to it. In short, to explode the absurdity, the writer must admit that he was once prevailed upon by a person with whom he acted, and who had heard much of the sparkling beauty thereby produced, to try this experiment; and, accordingly, he procured six quarters of peas, which he malted and brewed with barley in various proportions, and watched the wort and the ale very closely, but did not perceive any alteration for the better, which was precisely the result which he had predicted to arise from a speculation so uncommonly fanciful.

9. Fibrous Matter.—That before us was extracted from peas by Einhof, who published his experiments in the sixth volume of Gehlen's Journal. He says that it is much like gluten, but differs from it, and from all other vegetable constituents; that it is adhesive, will form paste, is perfectly insipid and inodorous, and insoluble in water, whether cold or hot, and begins to putrefy when commingled with it. This, from its description, appears to be a mass of unformed mucilage and gluten, into which the husks seem partially convertible, and differs from that other fibrous matter found

in rice by Braconnot, which consisted in a parenchyma (the integumentary amylin), not unlike that of oats, mentioned above, being knit together, filled with small bubbles, and was tender and succulent.

Lentiles and Beans.—These seem also to contain a quantity of fibre, starchy or otherwise, amounting on the average to not less than a fifth of the whole, the field-beans having the most, and the kidney-beans the least. They have plenty of what seems to be albumen, but no saccharum, or any real azotic gluten to produce it, and kidney-beans abound in mucilage; and all of them, as well as peas, and particularly lentiles, have too much of the substance called animo-vegetable to be preserved from putrefaction during any length of time, when once solved into their disorganised elements. Vauquelin and Correa de Serra found tannin in the skins of beans, and again in their animo-vegetable substance; and the only remarkable property which the former has found on a more minute series of experiments on a black species of kidney-bean from the Isle of France, appears to be "a black substance containing azote:" indeed, all these pulse darken the water in which they are boiled. The flour of lentiles, when digested in alcohol, gives to the latter a bitter acrid taste, and turns it green; and when distilled and mixed with water, it acquires a disagreeable smell. This shows that the animo-vegetable is pernicious; and though it is said to approach gluten in its properties, it has been proved by Einhof to differ from it in several particulars, as it soon putrefies when mixed with water, and gives out the smell of ammonia; therefore the brewer has no more to do than to discard this class of ingredients altogether. Playfair has reduced beans, and given the elements thus: C. 38·24, H. 5·84, Nitro-O. 38·10, Ashes 3·71, Water 14·11 *per cent.*

10. Phosphates.—In European rice we find thrice the quantity of these that is contained in the same sort of corn if brought from the Carolinas, ripe British barley affording something like a medium between them, but the unripe yielding none that is perceptible. Ripe peas seem to contain between two and three times as much as green pods, and beans more than thrice as much as peas. In some of the other cases they have been overlooked, or are included in the loss. The author once felt disposed to describe these curious salts, "formed by phosphoric acid," as Henry has it, rather particularly, and to show how plants draw them from the soil, as sustenance, till the seeds eventually imbibe and feed upon them; but as they are chiefly neutral, and the presence and quantity of each is dependent on the composition of the native soil, nothing needs here be said of them, more than that Liebig, the prince of agricultural chemists, declares that the seeds of corn *could not be formed* without the phosphate of magnesia; and that the alkalines, as well as those of magnesia and lime, are necessary for the production of all corn plants.

11. Albumen.—This substance has been named above (p. 46) as one of four derivatives from gluten, and as being thrice as copious in ripe barley as in unripe. Link, who is followed by Thomson, says that albumen and gluten resemble each other too closely to be considered distinctly; though the latter, in his more recent work, says, "it is unlikely that the constitution of the albumen, mucin, and glutin, should be exactly the same:" thus may men live and learn, while others unlearn what they have once known. The author, in exercising his own judgment with some degree of freedom, has learned to think with Liebig, that the critical repetition of another's experiments, or of his senti-

ments, must be viewed as a criticism upon his opinions. "If the result of the criticism be merely negative, and do not suggest more correct ideas in the place of those which it is intended to refute, it should be disregarded." Though Thomson's conviction has induced him to shift his opinion, and though he says, after all, that "little confidence can be put in M. Marcet's analysis," still he gives it without a better of his own; and perhaps that chemist thought the difference too trifling to notice; therefore let us take the following:

Gluten by Boussingault.		*per cent.*	Albumen by Marcet.		*per cent.*
O. 3 atoms	= 3·000 ..	25·	O. 2½ atoms	= 2·5 ..	20·95
H. 7	= 0·875 ..	7·292	H. 7½	= 0·9375 ..	7·55
C. 8½......	= 6·375 ..	53·125	C. 9	= 6·75 ..	56·55
Az. 1	= 1·750 ..	14·583	Az. 1	= 1·75 ..	14·65
19½	12·	100·	20	11·9375	100·

Which is a considerable difference in substances so nearly allied that they lately could not "be considered as distinct principles." The above, it is true, are the gluten and albumen of wheat; and though Einhof saw that they existed in rye and barley, and complained of the difficulty of separating them, they evidently do not vary far from these, though the gluten may differ in character. The analysis of animal *albumen* given in the "system" is O. 23·87, H. 7·54, C. 52·88, Az. 15·71, or nearly as the *gluten* of Boussingault. Another analysis of the albumen of wheat has O. with sulph. and phosph. 21·84, C. 55·01, H. 7·23, Az. 15·92; and Thomson again says, that no simple substance has yet been found in the animal kingdom which does not likewise exist in vegetables. This is particularly demonstrable in albumen, which has important engagements to fulfil, distinct from any other kind of matter: in fact, it is in both kingdoms the *primum mobile*, enveloped in a substance

peculiarly its matrix, and having an innate germ, appropriate to its own office and necessity. It is, in short, one of those "other substances besides starch, sugar, and gum," which Liebig says "*must* be present in a plant, if these are to take part in the developement of the germ, leaves, and first radical fibres."

In like comparison, also, gluten or *emulsin* may be considered as the milk or nutrient matter of seeds; saccharum as their blood, or the vehicular supporter of their life and motion; woody fibrin their bones; starchy fibrin their intestinal organs; mucilage their flesh or perishable substance; volatile matter their sudorific or other excrescent essence; starch their solvent sinews and tendons; oil their fat; amarin, extractive, animo-vegetable, phosphates, &c. their digestive food and alien matter; and husk and parenchyma their skin, membranes, and glands.

Albumen at 160° coagulates into a white solid mass, of a consistency dependent on the time that the heat has been applied, and in some measure, likewise, on its own quality; and the mass thus formed has exactly the same weight which it had in its fluid state. The coagulated albumen is insoluble, though when cold it solves in water; and this proneness to coagulate, through irresistibility of the power of heat, is a characteristic of the substance that distinguishes it from all others. Such is albumen, which the brewer is enjoined to bear particularly in mind when he examines the contents of his copper and the treatment of his worts. It is one of those essential properties of seeds to which the hackneyed word "gum" was applied by chemists before its distinct nature became known.

12. Diastase.—Another inherent property of seeds, which may seasonably be considered in connexion with albumen, is diastase (from διιστημι, to put at a dis-

tance; compounded of ἵστημι, to stand, and δια, between: a word signifying separation or disunion; being that principle which causes, according to another interpretation of the word, "breach of friendship" among the farinaceous constituents of the mash). Liebig, to whom we owe a debt of gratitude for the introduction of it, has laid down the following important principles:

The conversion of starch into sugar during the germination of grain, is ascribed to a vegetable principle called diastase, which is generated during the action of commencing germination; but this mode of transformation can only be effected by gluten, although it requires a longer time.

Seeds which have germinated always contain much more diastase than is necessary for the conversion of their starch into sugar; for five parts by weight of starch can be converted into sugar by one part of malted barley. This excess of diastase cannot by any means be regarded as accidental; for, like the starch, it aids in the formation of the first organs of the young plant, and disappears with the sugar. Diastase contains nitrogen, and furnishes the elements of vegetable albumen. The solution of diastase, whether it be pure or contain sugar, separates amidin from all starchy substances that contain it; and when heated to 150° or 167° with flour or starch, its extraordinary potency detaches the envelopes from the amidin, with which it then enters into combination, and causes it to form a solution in water, while the amylin separates, either falling to the bottom or floating on the surface. Such is the energy of the diastase, when thus engaged, that *one part* of it is sufficient to render soluble the interior portion of *two thousand parts* of starch, and to convert them into sugar; but it does not convert the obdurate

shell called *gum* into sugar, or act upon common sugar, or upon barm, neither is it necessary. This to the brewer is the key-stone of his art, and its truth is well grounded on French experiments, repeated in England; and it was in consequence of this property of separating the two constituents of starch from each other, that MM. Payen and Persoz gave it the name of DIASTASE.

Our celebrated professor has again determined, that sugar, gum, and starch, are not food for plants; but that carbonic acid, water, and ammonia, feed them when fully developed, the former serving, when accompanied by an azotised substance, to sustain the embryo, until its first organs of nutrition are unfolded; and that the quantity of gluten, vegetable albumen, and mucilage, will augment when the plants are supplied with an excess of food containing nitrogen.

Diastase is submissive when not excited, but resolute when forced into action. Though not soluble in alcohol, it is soluble in water and alcohol diluted. The aqueous solution has neither alkaline nor acid quality, and little taste, and when left to itself it will fret into acidity, the more rapidly the higher its temperature. It is not precipitated by diacetate of lead, but is obtained solid, white, and amorphous, in the following manner.

Macerate ground or crushed malt in water for some time, then press it; filter the liquid which flows out, and heat it to 158°. This will suffice to coagulate and separate the principal portion of an azotised substance existing in the liquid. Filter the liquid again, and mix with it alcohol till the diastase is thrown down, leaving the sugar, colouring matter, and the rest of the azotised substance in solution; and, in order to obtain the diastase pure, dissolve it twice more in water, and precipitate by alcohol as before; the azotised substance then is albumen, and we have the substances separately.

Diastase dwells in the seeds of malted barley, oats, and wheat, but not in the roots or stems of potatoes, except in the tubercles near the eyes, where it associates with an azotised substance as above, soluble, like itself, in water, but not in alcohol; but differing with it by not coagulating in water at a temperature from 169° to 177°, in *not* acting on starch, in being precipitated from its solutions by diacetate of lead, and in being eliminated by alcohol before the diastase precipitates.

As the different kinds of corn and the tubercles of the potato do *not* contain diastase *before* they have germinated, this shows the necessity of malting, without which no diastatic action can consequently arise; and because the value of diastase is super-eminent, a knowledge of the subject will be found available when we come to examine and describe the process of mashing, where will also be found some account of resin, another operative substance not contained in the Table above.

CHAPTER III.

MALTING.

BARLEY—TESTS OF SAMPLES—MOULD—THRASHING MACHINES—PURIFYING AND STEEPING—STEEPWATER—COUCHING AND FLOORING—DRYING—STEAD'S NEW PATENT—SPRINKLING AND ANTI-SPRINKLING—KILNS IN VARIETY—KINDS OF MALT—POOLE'S AND WHEELER'S PATENTS—CONSTITUTION OF MALT—TESTS—MILLS—ROLLS AND MAKERS.

Having in the preceding chapter disposed of all kinds of corn and kernel except barley, and of their constituents severally, we come at length to the remaining corn, and to the properties which distinguish it in the malting process; not that they are peculiar to the seed, but because they perform their functions with peculiar aptitude; and these, by nature, lead to the consideration of another part of our subject, namely, *the qualities of samples.*

Barley is the *hordeum* of the ancients. When the philosophers Fourcroy and Vauquelin triturated the unripe seed with water, it deposited a white powder, possessing the properties of starch; the water passed transparent through a filter, leaving a slimy substance behind it that possessed the properties of gluten; and when the solution was boiled, it deposited flakes of albumen; the liquid was then reduced to a syrup by evaporation, and this residue being treated with alcohol, and the solution distilled with water, the alcohol being subsequently distilled to remove some remaining gluten which went with it, a syrup was left with a sweet taste: thus was the saccharum of the barley obtained. In the treatment

of the meal of ripe corn, they also found the water depositing a white powder, which soon became acid, the acetous water itself reddening an infusion of litmus. This water held a large quantity of matter in solution, consisting of albuminous gluten, mucilage, saccharum, and a proportion of the phosphate of lime and the nitrate of soda.

In its maturity, the farina of barley contains a yellow powder, which looks like fine sawdust, and feels granular to the touch: this is the substance which in our Table above is inserted as "fibre," but which is called *hordein* by Proust, who discovered that the malting process converted it into starch, which is a point of the most considerable consequence, as the meal contains from 54 to 56 *per cent.* of it. Marcet has examined it in both states, and found its composition to be as here given:

Hordein of Barley.		Starch of Malt.	
Oxygen *per cent.*	47·6	Oxygen *per cent.*	51·8
Carbon	44·2	Carbon	41·6
Hydrogen	6·4	Hydrogen	6·6
Nitrogen	1·8	(No Nitrogen observed)	
	100·		100·

These numbers have led Thomson to treat the subject according to the doctrine of atoms; and thence to conclude that hordein loses one atom of carbon out of twelve by malting, and that the nitrogen of the meal is not inherent, but is imbibed by admixture with common air, and, if so, it is again alienated by malting. It appears from this example, and from the specimens at page 28, that malt-starch contains some 2½ *per cent.* less carbon than that of raw grain or potato; and that its oxygen is more by 4 *per cent.*, the hordein nearly coinciding with the starch of the raw substances, except that it holds some nitrogen in lieu of a portion of the oxygen held by the others; Marcet's starch of malt

coming within a half *per cent.* of Berzelius's *gum*, as given at page 40 above, in each of its elements.

Precisely in the same quantities are the elements of starch of malt given by Brande; and Thomson's account of hordein, in which he presumes to correct Marcet by the atomal system, is, according to the scale, $O.^{10}$ (10 atoms) = 10, the atom being unity; $C.^{12}$ (12 atoms) = 9, each ·75 or $\frac{3}{4}$; and $H.^{10}$ = 1·25, each ·125 or $\frac{1}{8}$; total, 20·25.

Then, as 20·25	:	100	::	10	:	49·38 O.		The Elements *per cent.*
*	:	*	::	9	:	44·44 C.		
*	:	*	::	1·25	:	6·18 H.		
				20·25	:	100		

But if we must examine the starch by the same test, we must quarter the atoms, and say, $O.^{10\frac{1}{2}}$, $C.^{11\frac{1}{4}}$, $H.^{10\frac{3}{4}}$, which give, O. *per cent.* 51·77, C. 41·60, H. 6·63, which is as near as can be approximated without absolute decimation of the atoms; and shows, that though malting the hordein has converted it into starch, it has not made an atom difference in any of the elements, but has added half an atom, such as they were, to the whole, and that to the oxygen, the carbon having lost what the hydrogen has gained. But, as the process makes great changes in the other constituents also, it may be as well to notice the system at large.

Malting.—To dissert on this expansive subject fully, might occupy much space; therefore, a few brief but necessary remarks shall suffice, merely embracing the principles and features of the most approved systems, in strict accordance with the doctrine of economy, as dictated by close observation during the extensive experience of many years that the author has prepared his own malt, and improved his practice by intercourse with others.

As the constitutions, energies, and vital functions of grain differ, more or less, according to the diversities of soil, climate, seed, season, and husbandry in harvesting, stacking, and thrashing, so is it necessary that the skill and experience of the maltster should be equal to the important task of selecting those samples of corn only which produce, by proper management, the richest and most uniform malts; he ought also to be unrestricted by arbitrary laws, and have full liberty to vary his practice in its manufacture, as the quality of his grain and attendant circumstances require, that his produce may at all times be as perfect as the nature of the grain, and his improvements from experience in working it, will admit.

The grain of barley, as shown in the Table, consists of sugar, starch, mucilage, gluten, a large quantity of hordein, and a hundredth part of a substance not bitter, but of a resinous character, which principles include some little oil and earthy matter. From these, in due proportion and combination, the plumula or acrospire, the radicle or rootlet, and the desirable saccharine matter, as well as the diastase that produces it, are formed by a healthy germination. When the grain is moist, it swells, decomposes, and evolves heat; the radicle is the most susceptible of these changes, as it soon expands, and conveys food from the moist exterior of the grain in contact with the wet, and probably from the atmosphere also, to the base of the plumula, through the inherent ducts of the cotyledon. While germinating healthily, the grain begins to emit an agreeable fruity aroma, if it have been kept sweet till put to steep, and the steep-liquor have been duly changed. The acrospire also swells, and gradually lengthens under the husk, and in a few days the end of the farinaceous matter, whence the root emanates, becomes friable and

sweet. This progression of the germinating and saccharising principle continues, under favouring circumstances, until the saccharum is considered to have arrived at its *maximum* of purity, when, to complete the process, to prevent waste by excessive vegetation, and also to preserve the sweet for timely use, the moisture of the grain is evaporated on a kiln: it now becomes what is called malt, and only requires freeing of its dried roots to render it fit for the brewer.

Such, in brief, is malting; yet, as in every thing else, a variation in the means adopted in its manipulation, during any part of the process, causes a difference in the product, and none more so than the two opposite and general practices pursued by the advocates of the sprinkling and non-sprinkling plans, although both parties claim the superiority, as rivals ever will.

SELECTION OF BARLEY.—The barley most suitable for being converted into malt grows on large hedgeless tracts of light calcareous land; and crops, excellent in quality, also grow on rich loamy soil; but much likewise depends upon the seed, which will impair after a few sowings on the same land. The best has a bright, clean, thin, wrinkled husk, closely adhering to a plump, round, well-fed kernel, which, when broken, appears white, chalky, and sweet, with a germ full, and of a pale yellow colour. On the contrary, barleys that grow on cold, moist, aluminous soils, have a thin kernel and thick coarse hide, are colder in their nature, and make malt very much inferior in flavour, and from 10 to 15, and sometimes as much as 25 *per cent.* inferior in the quantity of extract. The farina of many of these inferior barleys is of a yellowish colour, and breaks hard and flinty, whence they are avoided as much as possible by the wary, as the very best pay no more duty, and in many cases not so much, which is a consideration of

many shillings *per* quarter in pristine and ultimate value to the brewer who makes his own malt, the value of the additional extract often doubling the additional price paid for the raw grain.

Sugar-planters cut their canes before they have flowered, because they say that the nourishment which feeds the blossoms lessens the sweetness of the juice; and as corn is known to ripen twelve days after it leaves the sickle, and as a certain quantity of native moisture contributes to the contraction of the sweet principle when seasoning, many experienced agriculturists, rather than run the risk of having their barley shed or its ears broken off in the field, make a point of cutting it before it is quite ripe; but experience will soon convince an attentive observer that the ends of the malt made from barley thus husbanded incline to be steely, which is not so with the corn cut in its proud maturity.

Barley is not in a proper condition for malting until it has sweated and seasoned in the stack or mow two months at least. Artificial sweating on the kiln has sometimes been made an expedient with tolerable success, but is not so effective in dispelling the benumbing cause that prevents the grain from absorbing a sufficiency of pure water when in the cistern, as by a gradual decay and partial appropriation and dissipation of the superfluous and morbid moisture when in the stack. Sweated barley loses from a 30th to a 15th of its bulk, but generally recovers it again in the cistern.

The cautious maltster also directs his attention to any inequality of colour or size that may be in the samples presented to him, which act of care enables him to detect and avoid such mixtures as he knows will not grow evenly under the same circumstances, since it would be as impossible for a variety of barleys, or for the same barley differently housed and seasoned, to

make an uniform malt, as to train human beings under the influence of a contrariety of circumstances, and opposite sentiments and dispositions, to a concurrent system of thought and action.

The thin coat of barley, and especially that of the finer kinds, when stretched by the plumpness of the kernel, is closely attached to the farinaceous matter within, with which it is intimately connected by a spongy substance that valvularly feeds the interior from without, as from a series of syphons in mutual action, and is therefore better supplied with solvent principles in one condition than another, and consequently is readier for solution.

The writer of the Brewing essays remarks upon the great care necessary to be bestowed upon barley that has to be coasted to London in large quantities; after all which, if the voyage is prolonged by contrary winds, the whole cargo will spoil and become unfit for malting; and another writer on the same subject cannot believe that "ship barley" *ever* makes good malt, because he thinks it is *always* a mixture of various sorts. The essayist has laid down an axiom, that if barley, when it has been thrashed out, lie damp or exposed, it will soon lose its freshness, and smell strong and disagreeable, which, as he says, must depreciate its value. Like the Irish potatoes named in the foregoing chapter, such barley will also heat when on board, and is injured similarly to such as is overheated in a stack; the germ end of the grain turns to a blackish red colour, which denotes that the germ is killed. Take the skin off the germ end of the corn so discoloured, and it will appear shrivelled; but when uninjured, the germ is full; and if the skin be taken off, the interior will be found yellow, and will look like butter. It is also material to know that the germ of new stock is paler than that of old.

Another serious and indeed a vital injury inflicted upon the sensitive germ and its mother seed, is through the use of the thrashing-machine, which unfits them for malting by bruising and severing them. Such injured grain is incapable of vegetation, but *not* of putrefaction, which is evident from its blue-grey and mouldy appearance, and from the offensive effluvium which it emits upon the floors. Corn cut into sections does not germinate at all, and that with broken husks very imperfectly and partially; and even then the acrospire and solvent farina escape through the fracture, and the whole interior turns yellow and putrescent, tasting like rotten fruit, long before it reaches the kiln. The mephitic gases that emanate from this spoliation often impart a bad odour to the more perfect grain in contact; and besides the first cost and these evil consequences, the amount of excise duty is another weighty reason for avoiding the purchase of an article so expensive, and liable to such contamination, without producing one compensating quality. When the mould makes its appearance, the maltster is deterred from sprinkling, because moisture only aggravates the evil; yet, by this seemingly wise precaution, the brewer knows that he entails an injury on the same corns by denying them their natural sustenance, whereby the saccharising process is retarded, and consequently the saccharine production is limited in amount. The author has known the corns cut into two or more pieces to the amount of 10 *per cent.*, and with their coats cracked or torn as many as 15 *per cent.*, through being partially beaten off by the machine: the sight of such havoc is most conspicuous and deplorable just at the time when the grain is going to kiln; for it is then that these maltreated cripples, swollen by putrefaction in shapeless mouldy masses, give the whole body a blue and un-

sightly appearance, and an unpleasant odour, like exhumed bodies of martyrs risen up to appal the assassins that sent them prematurely to their destiny. In drying and turning on the kiln, nearly the whole of the mould tumbles off like a blue powder, and falls through the kiln, and the remainder passes through the screen; but the dried putrid farina remains, and its effect in the mash-tun is to stop the pores of the mash, a great proportion of it dissolving, and thereby preventing the wort from coming off bright. It is worthy of remark, that so strong a tendency has such wort to commence fermentation, that no barm is required to excite it at pitching; indeed, upon consideration, we know that some portion of the wort, being, in this particular case, an azotised matter, is in a state of putrefaction which boiling does not totally annihilate; for it is of the same identical constitution, and in the same condition, as yeast itself, and, consequently, it acts in the same manner, and with the same effect upon the saccharine principles accompanying it during fermentation, but yet more energetically, probably from being more equally diffused and in closer connexion.

Worts invested with so much putridity have been known to attenuate from 26 lbs. (being common stout) down to 8 lbs. in the space of forty hours; and in the winter season, when the heat of the gyle did not exceed 61° at any time. Here the brewer's interest is in unison with that of the poor agricultural labourer; for the flail and steady honest manual labour of the poor man is far preferable, in a commercial and domestic view, to this rough misapplication of the non-compensating machine, which, in this instance at least, robs the defenceless man of the means of earning a few shillings through the severest and dullest part of the year, when the other

avenues to employment are closed against him; and which injures the trader and traduces the name of the working farmer.

STEEPING.—This is generally done in a slovenly and unscientific manner, one uniform time being observed, whether the grain requires more or less. It would be better for both maltster and brewer, if all the grain used were carefully screened before steeping, because the thin light corn pays duty, becomes exhausted in malting, and fills the measure without imparting one-fourth enough of saccharum to pay its cost. Some maltsters run their barley over a short screen, placed between the store or garner and the cistern; but the screening which it thus receives is very impotent. Running the water into the cistern first, rousing and slowly washing the grain in, and skimming off the bruised, cut, and light husky corn, with the chaff and dirt that may accidentally accompany it, is also advisable; and to do this with ease, one edge of the cistern might be made lower than the others, to allow the water and swimmings to flow away over that edge, to fall on a fine grating while the grain is being roused into the cistern.

The first principle in Stead's new patent, dated March, 1843, consists in propelling a current of heated air against the grain, and thereby cleansing it as it falls into the cistern.

The quantity of liquor imbibed by the barley when in steep greatly influences the future quality of the malt, and depends upon the time that the grain is allowed to remain in the cistern, the temperature of the steeping-liquor, and the quality and condition of the grain. The bolder and heavier kinds of barley are seldom steeped long enough, and, in fact, every maltster throughout the country drains his cisterns from

twelve to twenty hours too soon, especially in very cold weather, and when he uses river-water, or any other that has been exposed to the atmosphere.

The temperature of the steep-water does not occupy the attention of the inconsiderate maltster, since all that he requires is liquidity; yet it must be evident that grain will absorb a much greater quantity of water from a well, which is usually at 52° or 53°, than of river-water ranging from 33° to 40° in winter, the same length of time being allowed for steeping in each instance; and, upon the same principle, less well-water than river-water will be imbibed when the latter is raised by atmospheric changes to 66°, and means should be at hand for regulating the temperature accordingly; and the grain should not be removed from the steep-water so long as its nature requires further imbibition.

The future sweetness of the malt is materially promoted by frequent changes of liquor, though the officers object to more renewals than one, which certainly is insufficient in mild weather; but it is better to replenish once than not at all.

The legislature directs that all grain shall be steeped forty hours, or "so many hours longer as shall be found necessary." From forty-five to fifty hours is certainly quite long enough for the cold thin rubbish which ought not to be steeped at all; but the stouter and finer wettings require from sixty-four to seventy-two hours in the cistern, to saturate them sufficiently under ordinary circumstances, which is, until the husk will separate from the kernel on being pressed at each end between the finger and the thumb. Attention to this particular is highly essential when it is desired to make a perfect and rich plump malt, regardless of a charge of five *per*

cent. more duty which the additional swell will produce, but which in reality pays nothing extra, if measure and quantity of extract be considered, as shall shortly be shown; yet some maltsters who make for sale, being regardless of saccharine production, and wishing to pay as little duty as possible, purposely steep only for short periods, in order to prevent the enlargement of the kernel: it is needless to say that no sensible man would be guilty of such absurdity, or encourage such ultra-penurious practice in others.

COUCHING.—The grain, having steeped long enough to saturate its farina to the centre, is now drained and thrown into a frame called a couch, where it lies about twenty-six hours, during which time it swells a little higher, generates heat, and emits some carbonic acid gas, giving proofs that the process of germinous fermentation has commenced; and this is the chief purpose of couching. Here the excise obtains the greatest gauge, and fixes the duty, accounting the greatest "tell" the most correct charge. The average increase of bulk is little more than a fifth, and "the law presumes that the swell will amount to 18½ bushels for 81½ bushels before steeped;" but if the barley was bold and dry, the malting brewer would find it much to his advantage if the increase amounted to a fourth; that is, if 80 bushels gauged to 100 in the cistern; for it is of the utmost consequence that the grain carry with it a sufficiency of moisture to supply the operations of nature till the first sprinkling-day, which by law is the seventh; for by the 1st Vict., c. 49, sect. 7, "a maltster may sprinkle a floor of grain which has been kept in the cistern covered with water the full space of fifty hours, at the end of six days, or 144 hours."

If the sides and floor of the couch-frame were perforated, it would facilitate the change of air, and

equalise its temperature throughout the body of the grain.

Flooring.—The barley, having been removed from the frame, is to be spread considerably thinner, that too much heat may not be generated, and that the rootlet may not be too speedily elongated. The art and attention of the maltster are now demanded to regulate the temperature of his *pieces*, and influence the growth and form of the radicle; for which purpose a thermometer is sometimes useful, and particularly when the atmosphere is under 40°; but when above this, it is seldom of practical service, because the pieces cannot be cooled below 40° by either thickening or thinning, or yet by turning; and these are all the means of regulating the heat which the maltster has hitherto possessed, he having been all along a full century behind the brewer in mechanical contrivance and philosophical research, though he might easily have provided himself with *attemperators* suitable for the purpose. A new era, however, has now opened through Mr. Stead's patented "Improvements in the Manufacture of Malt," already noticed; the second of which is the application, through the medium of pipes, of steam, cold air, or watery vapour, in order to facilitate germination under any state of the atmosphere; raising the temperature by steam in cold weather, reducing it by cold air when the floors are overheated, and moistening the air by the vapour when the weather is windy or the grain too dry. His pipes are furnished with stop-cocks, to allow the steam or vapour to escape at pleasure, and they may be laid along the floors or suspended from the joists, or the floors may be made double, from three to six inches apart, the upper perforated, and the pipes inserted between them, so that the heat or vapour may ascend through the holes. His third improvement may like-

wise be noticed here, which is, a mode of propelling any of his fluids through his pipes into the malting-house, by means of fans, to regulate the air of the place.

As a thermometer may be of some occasional service, the author would next suggest that its frame be of metal rather than wood, as the latter is a bad conductor of heat, and the temperature of the frame influences the mercury so much that considerable time is required to examine the exact state of the pieces into which it is newly inserted. It should also be pointed at the bulb end, that it may the more easily pierce the grain. If possible, the young floors should not exceed 50° in warmth, and should be turned once in every four or five hours at the longest; bearing in mind that the lower the temperature, if not below 45°, the more gradual is the progress of both root and spire; the thicker, more numerous in fibres and bushy will the root be; and the more general, natural, and uniform, the decomposition of the imbibed water and of the farina, by which it is especially appropriated. These are objects which the active and thoughtful maltster—for a few such there are—regards with concern; though we must admit that he is sometimes foiled by circumstances over which he has had no previous control, such as the constitution of the corn, the state of the weather, and ridiculous laws!

Unless the floors are duly turned and kept cool, the smell of the moist grain will become unpleasant, and the radicle will consist only of a few long weak filaments, entwining around each other like *boas*, and imparting but little nourishment to the acrospire. As these floors become older, they increase a few degrees in warmth, but should never be allowed to ascend above 56°, if possibly avoidable. The roots and spire now gather length and strength, and the kernel becomes white, mealy, and sweet; these indications continuing

to show themselves with greater conspicuousness as long as the germination is progressive, and the grain sweet and healthy, which, however, seldom extends beyond the sixth day. At the termination of the restricted period, the corn is allowed to acquire a replenishment of one of its principal recreatives, *viz.* water, which must be greater or less, according to the previous dry or foggy condition of the atmosphere, the time it has been in the cistern, &c.; but it usually requires from one gallon to two upon each quarter. We know that it is the practice of those who water their floors as a principle, to use twice and even thrice this quantity at once; but there is an objection to this excess, because some of the grain in the nether region of the piece receives too much water; and hence it is far preferable that a smaller quantity be applied at every turning, or at least at each alternate removal, or indeed as occasion may require, till the termination of the ninth or tenth day, when it may be discontinued; and about four or five days more will be quite sufficient thoroughly to saccharise the corn, and to consume and evaporate the chief part of the moisture; and it is then fit for the kiln. As it is deemed of the utmost importance that the germination be not allowed to flag between the couch and the kiln, and that it may receive the first effects of the fire of the latter while full of life, health, and sweetness, the absurd custom of *withering* is here dispensed with as a folly.

As regards the criterion to be observed in the growth of the root and spire, the author knows from oft-repeated experiments that the former need not exceed half an inch in length, that it is never too bushy or too strong, and that the latter cannot be too long while confined within the limits of the husk, though sufficiently not to shoot through upon the kiln, unless the barley is so

superior through its chalkiness, that it is literally half-malted before steeping; which kind of grain requires less than ordinary sprinkling.

The next operation is that of drying; but here we may properly stay to reply to the principal charges brought by maltsters who do not apply water to their floors against those who are desirous to do it periodically.

OBJECTION 1.—*Unwatered malt is from* 30 *to* 40 *lbs. per quarter heavier than that which is watered.* REPLY.—Unsprinkled malt usually ranges *from four to ten lbs. per* quarter heavier than sprinkled, if the barleys were originally equal in quality and condition; but weight is no criterion of the goodness of malt, though it may guide the buyer of barley. The non-sprinklers admit that where the vegetation of the grain has been imperfect, the product is faulty, and yet heavier than good, being partly malt and partly barley; which argues against their own theory of perfection. Little do they incline to think that the more oxygen the grain absorbs while germinating, the lighter the malt becomes; and yet they properly admit that the imbibition of this gas is necessary to the conversion of the farina into saccharum, though they unwittingly fall into the same error as Mr. Reynoldson, who was their chief opponent in 1808, in supposing that the increased weight of their grain is attributable to such acquisition; which is absurd. The unsprinkled is heavier, not because it is more oxydised, and consequently sweeter, but from the opposite cause of deficiency in the appropriation of oxygen; and hence its greater weight is only a proof of its less full conversion from barley to malt.

OBJECTION 2.—*The root is the vehicle by which the oxygen of the atmosphere is conveyed to the interior, and the formation of saccharum is in proportion to the appro-*

priation of that element by the farina. REPLY.—Admitting this principle, still the most skilful of all these advocates of starvation have not shown that the cotyledon, *when immersed in steep*, is furnished with air-vessels for the conveyance of this especial element from the aërial regions. Perhaps it will be safer to suppose, in the absence of better evidence, that the main source of the oxygen is decomposed water, particularly as this contains three-times more of it than air; but be this either way, it does not militate against the sprinkling system, since we know that the starch of the grain is oxydised in a fifth of the time occupied in the *dry* process of oxydation.

OBJECTION 3.—*When the floors are watered, the heat increases, and an equable heat cannot be preserved; which causes flinty malt.* REPLY.—" Vain reasoning all, and false philosophy." This also appears to emanate from parties who judge theoretically, and without having ever paid practical attention to the subject. Every one knows that moisture increases the evaporation of caloric, and that in the East the same principle is applied in cooling wines and freezing liquors, as well as in surgery and the use of lotions. The truth is, that the generation of caloric is checked or removed under the sprinkling system, and that the pieces are many degrees cooler than the unsprinkled can possibly be: this some of the non-sprinklers know; for they grant that to promote the growth of the acrospire, they lay the grain a little deeper, and keep gradually increasing its thickness up to the kiln. It must then be clear that this deepening of the pieces is to preserve the moisture, and to increase the heat.

OBJECTION 4.—*Some of the corns get so much moisture, that it causes the mould.* REPLY.—The sprinkling is not intended to be done in so slovenly and prodigal a man-

ner as to give any of the floor a surplus supply of liquor; yet, were this the case, it could *not* cause the mould, unless the grain had been previously injured, and then the mould could not be attributed to any particular system of procedure in the malt-house. Besides, the mould also originates in an extreme putrefaction of the gluten, which by contagion affects the albumen, mucilage, &c., a species of decay which cannot take place where a due provision of coolness, and the necessary fresh moisture for the preservation of vitality is observed. This may not always be done; but we must not condemn the system upon the error of the individual who negligently professes it.

OBJECTION 5.—*The non-sprinkling plan is the most natural, clean, pure, and free from adventitious flavour.* REPLY.—As the natural process of vegetation is subject to a constant supply of the elements congenial to its growth, the chief being a regular accession of fresh moisture, which is derived from the soil, rains, fogs, &c.; and as the anti-sprinklers purposely withhold such nourishment, and prevent a free circulation of atmospheric air by heaping their grain together, their opinion of a "natural process" is paradoxical; and besides, their roots are flaccid, brown, and enveloped in their excremental gases, which render the grain the reverse of clean and pure, and free from a sour and putrid flavour, which sort of flavour they necessarily mean by the word "adventitious."

OBJECTION 6.—*A cautious and artful maltster may defraud the revenue of half the duty which he ought to pay, and yet incur very little risk of detection, provided he is indulged with watering the short wet corn on the floors.* REPLY.—He cannot be guilty of vast defraud, if vigilantly watched by the officers; and if he could, that

would not be a just cause for depriving the honest and most respectable of the more skilful portion of the malting world of the best and most philosophical means of making good malt; and they constitute a majority: neither is it right to deprive the brewer and the vast ale-drinking community of the eminent advantages they ought to reap from the advancement of science in the production of an article, which derives from its employment a honey-like richness of extra-superior quality, naturally healthy and well-made.

OBJECTION 7.—*The vegetation of the sprinkled corn is forced, and is consequently pernicious.* REPLY.—This charge is rather obscure; but if by "forced" is meant *expedited*, it is admitted; but expedition and force are two things, and it does not follow that either of them leads to pernicious results; on the contrary, enticing, so far as it fattens the malt by repeated applications of good, wholesome, and natural food, and only when the appetite demands it, cannot be pernicious; and reason, experience, and the saccharometer, prove the fallacy of the charge. But to force by means of an accumulated amount of caloric, generated amidst mephitic gases, purposed starvation, and partial putrefaction, prolonged through five or six days more than are required by the other method, is *really* pernicious, because the efforts of nature are paralysed, and the local suspension begets flints and a gritty mealiness, besides a deficiency of both saccharum and flavour.

OBJECTION 8.—*The watered barley throws a fresh root after sprinkling, and the old root is purposely beaten off in turning.* REPLY.—The form and number of the fibres are points of solicitude with the observant maltster, but their length is not so much an object with him as their number, strength, and healthiness, on

which their power in only conveying fresh supplies of food to the acrospire and kernel through fully extended and vigorous ducts, mainly depends; and although some of the roots may be beaten off in turning, it is never intentional, but merely accidental; and if fewer roots are lost by the non-sprinklers, it is because their pores have collapsed, become tougher and more fibre-like, and, of course, less capable of conveying the oxygen, of which they are so solicitous, from the atmosphere, in which it awaits their bidding.

Objection 9.—*One of the evil results of sprinkling is a large strong root and spire, and therefore a needless exhaustion of the kernel.*

Reply.—This, to theorists, may appear plausible enough, yet it is also erroneous, and for these reasons:—Although the radicle and plumula are certainly stronger in the watered than in the unwatered specimens, yet their size does not arise from the solid of the kernel alone, but in a great measure from the decomposition and self-appropriation of such fluids as are occasionally presented to them through the watering-pan by the nursing maltman; and, moreover, such constituents of the grain as enter into the composition of the roots, consist chiefly of the least valuable and most objectionable parts, namely, the gluten and hordein, which they assist in reducing; these appear to be the cementing or cohesive principles of the barley, of which it is necessary to dispose to facilitate the preparation of the saccharum; and as these, including the albumen, are the most perishable parts of the corn, it follows that their removal by the root or otherwise, renders the malt more suitable for brewing ales in hot and precarious seasons, and, indeed, at any other time; the saccharised starch and other valuable matter being intended by nature to enter

into the composition of the acrospire or future stalk as it proceeds, that it may constitute the germ of its own kind; yet, as the spire is never allowed to arrive at that age, strength, and condition, when in the maltster's hands, which requires those precious fundamental principles, or is in a fit state for their reception; any other appropriation in this respect, or any needless exhaustion of the kernel, cannot be fairly attributed to the more vigorous system engendered by sprinkling. In fact, a long or large root does not spring through the course of necessity, but is the casual consequence of an operation; for in some particular wettings of grain, a full formation of saccharum is evinced without any extension of the rootlet, and in some instances the mere appearance of a rootlet is all that is put forth; and whether it be large or small, the spire and root subtract the elements of the starch and other solvent matter, in appropriate portions for the formation of sugar; and sugar can be made, though not so freely, without germinating the corn at all. Again, it is necessary to remember, that it is not until the spire breaks forth into light, that the kernel begins to liquefy to feed it: hence the precaution of all maltsters to stop the vegetation by drying before such an accident occurs, some allowing the spire to extend two-thirds, some three-fourths, and others seven-eighths, up the back, according to custom, conviction, or notion.

OBJECTION 10.—*Unsprinkled barley emits a vapour upon the kiln, which shows that it carries with it water enough from the cistern to malt it completely.*

REPLY.—This is no proof that the escaping vapour may not be so far exhausted, so contaminated, and so dissipated in the grain, that it has long been unfit for affording any further support to the germ, or for pro-

longing its vitality. The grain must be drier than it was before steeping, were it to emit no vapour upon the kiln.

OBJECTION 11.—*Another object in sprinkling, is to increase the measure some ten per cent.*

REPLY.—The measure is certainly increased, but the accession of bulk to the maltster *is not half so much as ten per cent.*: it would be better if it were so, provided that the other advantage of above five *per cent.* increase in fermentable matter, which is insured by the sprinkling system, could at the same time be retained, to afford some compensation for the increase of duty available to the excise.

OBJECTION 12.—*Watered malt yields from twenty to thirty per cent.* LESS *extract than unwatered.*

REPLY.—This is a wide, and undoubtedly a wilful, mistake, and may more properly be called a perversion. The author has repeatedly taken experiments during several years, in order to meet this assertion demonstratively; and the following is the average result, which establishes the superiority of the sprinkled corn over the unsprinkled, upon a ground that any other fair series of experiments will prove to be undeniable:—

TREATMENT.	Quarters steeped.	Measure when dried and screened.	Weight *per* bushel.	Quarters mashed.	Extract *per* quarter.
Sprinkled ..	25	26·3	40¾	25	90·4
Unsprinkled	25	25·6	41½	25	86·2

Showing, that though the additional increase in measure, or outcast, is not three *per cent.*, the additional extract from an equal quantity brewed is 4·2 upon 86·2, or 4·87 *per cent.*, completely contradicting the assertion of the non-sprinklers. One thing that ought to be

noticed is this, that the husky barley gauges much more in proportion to its original bulk, both in the cistern and the couch, and consequently pays more duty than the bolder kinds, which are the best; but here we have an outcast to counterbalance some of the loss sustained by steeping, flooring, waste, &c., estimated in the report of the Scotch commission at eight *per cent.*, provided our barley have been good, besides obtaining the preference in the market, as a reward for extract and flavour. To the brewer who makes his own malt, the comparative value stands thus, supposing that his malt in each case stood him in 58*s.* *per* quarter; each malt having been screened once, and alike:—

	£.	*s.*	*d.*	£.	*s.*	*d.*
25 quarters sprinkled at 58*s.*	72	10	0			
105 lbs. additional extract on 25 qrs. brewed, at 8*d.* . .	3	10	0			
10·4 bushels outcast, at 7*s.* 3*d.*	3	15	5			
				79	15	5
25 quarters unsprinkled, at 58*s.*	72	10	0			
4·8 bushels outcast, at 7*s.* 3*d.*	1	16	0			
				74	6	0
				5	9	5

Extract from the outcast, sprinkled . . .	1·3 qr.	117½ lbs.			
Ditto, unsprinkled . .	0·6 qr.	51¾ lbs.			
Difference saved on outcast alone . . .	0·7	65¾ lbs. at 8*d.*	2	3	10
Total extra profit on 25 quarters steeped . .			7	13	3

Being 10½ *per cent.* upon the *outlay* in favour of due and wholesome sprinkling, but not upon the *measure.*

We may again observe, that the difference in the measure is caused by the strongest roots of the watered corn not breaking off so near the end of the grain as those of the unwatered, and that the root end of the husk is also more extended by being occupied by the stumps of thicker and stronger roots, so that the corns keep one another farther asunder in the measure; and this is a more correct way of accounting for a decrease of weight, than by supposing that it is occasioned by the exhaustion of the kernel by germination.

Kilns and Drying.—The limits of this publication prevent any lengthy observations on the structure, advantages, and disadvantages of the numerous kinds of kilns on which the drying part of the process is effected: it must suffice to suggest, that the drying-floor should be sufficiently capacious to accommodate a whole steeping at once, at a moderate depth of from eight to ten inches. The floor may consist of hair-cloth, pierced iron, tiles, or wire; but the latter is preferable by far to any thing liable to choke up, and affords a readier access and more equal distribution of heat to the grain. It is also suitable for imparting any gradation of colour, from the palest to the brownest, though a little more attention to the fire may be necessary when drying pale malt upon the wire, than is demanded by the tiles. Cokes, anthracite-coals, dry and green wood, and peat, are used for this purpose, according to locality, price, and the colour in request; that which dries off the greatest quantity at the smallest expense, without impairing the flavour of the malt, is the best. In some instances, hot-air tubes, leading from the furnace, fire-place, or hot-air chamber, and some two feet through the drying-floor, have been adopted, and found

to answer the purpose remarkably well, in rarefying the moisture and air that hover on the surface of the grain, and thereby causing it to ascend directly through the corn, instead of the maltman having to turn the sweating and refrigerating corns to the bottom, again to cause the rarefaction and condensation of the moisture and vapour in their passage from the wire through the cold surface. By this contrivance, besides a saving in fuel of from 10 to 15 *per cent.*, the flavour of the malt is preserved, through not being exposed so repeatedly, after the commencement of drying, to the vicissitudes of heat, cold, aridity, and humidity, and, consequently, by being subject to less evaporation of the aroma of the malt, which inevitably escapes with the vapour. A wire tube placed in each corner of the drying-room, descending through the floor of the kiln, and standing about eighteen inches above the grain, will be of similar utility.

When a steeping is dried off at two, three, or four times, the first kiln must either be malted too little, or the last grown too much, either of which casualties will present inequalities in the sample; and besides this, as much less time and more heat are thus engaged in drying each separate portion, there is a danger of refixing the gluten, and enveloping the partially converted hordein and starch together during the drying; and in this way, much hard, steely, and brittle malt, may be accounted for.

A great improvement in the process of drying malt has lately been effected by means of Stead's patent, already referred to, through the propulsion of air heated between the propelling fan and the kiln, and raised to a higher or lower temperature, according to the colour which the maltster is desirous to impart to his specimen. By another contrivance he draws the air from

the kiln by a fan: the kiln being made as nearly air-tight as possible, the fan is applied above it, and causes the current of heated air from below to pass through the vacant space for the purpose specified.

Another of his novelties is the introduction of "Tower Kilns," consisting of a range of four kilns, one above another, so that when the quantity is large, he first charges the uppermost kiln, and when it has remained there awhile, runs it upon the second, and charges the top with a fresh supply, thus continuing to lower it from kiln to kiln, till at length it is drawn at the bottom: thus each portion receives equal treatment, or any may be altered if the first have been unsatisfactory. Here, too, he applies his fan as before, "to facilitate the drying process."

Upon the whole, Mr. Stead's plans, of which this is the last, appear to the author to be decidedly meritorious, and admirably adapted to extensive concerns where intelligent workmen are kept.

A thermometer about two feet long, with a scale of some eight inches' range, the frame pointed at the bottom as before directed, and extending four or five inches below the bulb, is indispensable where uniformity is desired. Here this instrument may be used to considerable advantage, as the maltman may regulate his fire or his dampers according to the degree of heat required to pass through the grain during any period of the process.

Pale Malt.—The most profitable manner of drying pale malt is to do a whole floor without hindrance, and slowly to occupy from three and a half to four days in the operation. During the first twenty-four hours the heat may be maintained at 80° to 84°, and the malt *must be* turned once or twice with a fork. In the second twenty-four hours the heat may rise from 6°

to 10°, and the kiln must be turned three or four-times more, the heat not exceeding 90° at the end of the second day. On the next day it may range from 95° to 98°, the turning being continued as before; and during the last twenty-four hours the heat may be allowed gradually to advance to 120° or so, and for malts less pale proportionably higher.

Pale malt for India ale should be dried on kilns at least fourteen feet above the fire, in which case the air-chamber will be capacious and lofty. The furnace should be constructed so as to enable the workman to exercise the utmost control over the hot and cold currents for several hours without his attendance; and in all cases some hot-air should be made to pass direct from the furnace over the corn in upright tubes, as mentioned elsewhere. It is preferable to unload the kiln without damping the fire or permitting the malt to cool; and this being done, to screen immediately and store away hot in a close dry room. Some experienced maltsters contend that it is preferable to trample off the root and store it away with the malt, because it fills up the interstices and excludes the air; while others, who make for sale, say that it acts more effectually if left on. The best way is to tread off the root, all over the malt, as a covering; but the salesman maltster had rather decline screening till his malt is sold, that it may remain light in an open store, and swell a little by the effect of the atmosphere playing through, which will also toughen the roots to prevent their breaking off close to the husk; but these considerations cannot serve the malting brewer, who calculates his profits by that unerring instrument the saccharometer, and to whom richness and aroma are so desirable and so valuable.

Brown Malt is made and dried in a similar manner to pale, excepting that before it is perfectly dried,

a little water is sprinkled over it upon the kiln, to give flexibility to the husk; and the drying is finished by a brisk heat derived from dried beech or other timber, and during this latter part of the process the grain is not above two inches thick, and is constantly being turned.

Another mode of high-drying has recently been adopted by the late Mr. Poole, of Camberwell New Road, who, in November, 1843, took out a patent for the merit of having combined rotatory motion in connexion with a cylinder, heated exteriorly by an oven or furnace, though he has laid no claim to the invention of the cylinder itself, which has long been used as a *roasting* apparatus; and it is clear that in this application of the principle it will either roast or merely dry, though he titles his scheme "improvements in *drying* malt." His mode of procedure specifies to put his malt into a cylinder of wire-cloth, placed within the iron one, in an oven or the flue of a furnace, the cylinder having arms by which it is fixed to a hollow shaft, made to revolve by hand or otherwise. The heated air then passes inwardly through the wire-cloth to the grain contained within it, which it permeates, and escapes out again through the hollow shaft, one end of which is prolonged outwardly from the oven, so that by the aid of a rack and pinion the cylinder may be drawn from the oven at pleasure, as the state of its contents may require. The oven is closely fitted with doors both at the place for withdrawing the cylinder and also at the exit end at which the heated air and gases issue; and thus, when the cylinder is in action, no air, &c. can escape except through the drying grain, and thence by the prescribed channel.

Blown Malt.—Another method of making brown malt, which is followed by most of the maltsters in and

around the metropolis, is to lay the vegetated barley on a wire-kiln, in a tolerably moist condition, from half an inch to an inch thick only, and immediately to dry it off with blazing straw, where it can be had, or more usually with wood, where straw, whin, or fern is not procurable, keeping it constantly in turning by men with shovels, who, through the intensity of the heat and fumes, added to their labour, are nude with the exception of drawers and clogs. The grain thus expeditiously dried has the term blown malt applied to it, through having acquired an unnatural size from the sudden expansion of the husk by the forcible rising of the farina and steam within.

Porter or Black Malt, commonly called Patent malt, from a patent granted for the invention and manufacture of it in 1817, to Daniel Wheeler, of the parish of St. George, Middlesex, is the legal colouring matter used in porter brewing, and is prepared by roasting common pale malt in cylinders, like coffee, at a heat of 360° to 400°. These cylinders, constructed of thin iron, are made to revolve over an enclosed furnace, till the malt within them acquires sufficient darkness of colour to answer the purpose intended. This preparation is by some thrown into the copper with boiling worts brewing into ale, merely to extract its colouring matter, which is done without solving its farina; others mash it with their ordinary malt; and a third class put part into the mash-tun and part into the copper. Any kiln of unvegetated or deaf malt, or brown malt which has over-dried, may be turned to this purpose, if scorched till unfit for brewing into ale. Wheeler's patent superseded the use of *essentia bina*, or sugar wort evaporated to a treacle-like consistency, the sale of which had been monopolised by the celebrated Alderman Wood.

Constitution of Malt.—We see, by the analysis of barley and malt, given in the foregoing Table, that the hordein or matter of barley decreases 43 *per cent.* by the malting process, that the sugar increases 10 *per cent.*, its parent starch 22 *per cent.*, and the next kindred ingredient, mucilage, 10 *per cent.*, the hordein having assumed the character and constitution of one or the other of them, according to the degree of transmutation that it has undergone; whilst the gluten, containing of course the albumen, has diminished two-thirds, and yet left sufficient remaining to carry on the work of future conversion; whence we once more infer that the hordein, which is the crude ingredient, first yields starch in malting; that this portion afterwards gradually becomes sugar; and that the gum of the first formation is the first also to yield sugar by transition; and by parity of reasoning we conclude that the gum yielded by the bursting starch, which the analyst has here confounded with mucilage, was the last formed, and had not time, while on the maltster's floors, for farther transmutation into sugar; but we do not by any means charge the trader with the imperfection, because, if he had humoured the farther progress of vegetation till more of the hordein had become starch, and the starch already formed had more of it become sugar, neither he nor the brewer would have been any gainer thereby; for, as before observed, both the acrospire and the radicle are principally nourished and maintained by the newly formed fluid sugar after the former breaks through the husk; so that it is better to stop here, and to transmute the remnant by some subsequent mode of treatment less hazardous, since an extension of the malting process would present even less saccharum than now matured, as the longer and hardier the blade grows, and the more lengthy and ramified

the rootlets become, the more of this sweet nutriment they require to devour for their support; and if left to the care of nature alone, they would completely empty the husk.

The analysis of barley chosen for the Table is not quite so exact in numbers as one of barley-meal by Einhof, who has starch and hordein 67·19, saccharum 5·21, mucilage 4·59, gluten 3·52, phosphates 0·24, volatile matter 9·38, husk 6·77, albumen 1·12, undescribed 1·98. In some of the leading particulars the two accounts differ but little, yet it appears that full 20 *per cent.* of that which Proust could save in transmutant or convertible farina, was lost by Einhof in separating his husk from the substance, and permitting a quantity of his meal to evaporate and fly off in volatility; and that the material which one separates as albumen, the other has passed unnoticed or classed as resin, and neither of them has noticed the oil.

The character given of resins is, that they abide in almost all plants, and in almost every part of the plant; that they are tasteless and inodorous unless they *retain* some volatile oil; and that they are kept in solution by that oil when extracted from the plants that bore them; but that when the oil becomes exposed to the air, it either escapes or is *converted into resin* by the absorption of oxygen. Thomson supposes that resin is in reality volatile oil, not only combined with oxygen, but also deprived of some of its hydrogen, and splits the opinion as to its destination with Proust, who says that "when volatile oil is exposed to the air, it is partly converted into a resin and partly into a crystallised acid." Well, therefore, may the 2 *per cent.* lost in Einhof's analysis through his haste to evaporate, include the 1 *per cent.* observed by Proust in his cooler process. Such is the ready fate of the resin of barley or

malt, which, by its solution and dilution, tinges wort with a golden colour.

We have seen that green barley is one-half volatile matter, including the oil; that meal does not contain 10 *per cent.*, though, according to Einhof, barleycorns contain 43 parts in 384, or rather more than 11 *per cent.*, though its resin amounts only to 1 *per cent.*, which it retains in the state of malt; and this shows that the whole or most of the matter accounted volatile gradually disappears, except the oil, which will go likewise, unless by chemical synthesis it combines with oxygen to form the more concrete substance which is found to be a species of resin.

The necessity of preserving this transient qualification of the barley, which is done by malting, is better known and more appreciated in the distillery than the brewhouse, as it is asserted that whiskey owes its peculiar flavour to "a volatile oil that exists in the barley," and which is known to dissolve in six-times its weight of alcohol, or double its weight of ether. Hops yield a similar substance, for when they are digested in alcohol, chemists find a greenish yellow solid matter, consisting "partly of oil and partly of resin;" but the older the hops, the more resinous it is; which again shows that the volatile oil progressively transmutes and becomes more concrete in its nature; and then, according to Payen and Chevallier, who have tested it, it will require water ten thousand times its weight to bring it into solution.

Resins, as appears from various authorities, generally contain from 77 to 83 *per cent.* of carbon, and about equal quantities of hydrogen and oxygen; and best volatile oils from 80 to near 90 *per cent.* carbon, and little oxygen or none, and are devoid of nitrogen also.

We will now take the elementary principles that constitute the more prominent characteristics in the transmutation of malt, and compare them relatively.

Elements.	Symbols.	Hordein.	Starch of Malt.	Gum or Mucilage.	Sugar of Malt.	Gluten.
Oxygen	O.	49·39	51·8	53·09	56·71	22
Carbon	C.	44·44	41·6	41·4	36·2	55·7
Hydrogen	H.	6·17	6·6	5·51	7·09	7·8
Nitrogen (Azote) ..	Az.	..	..	..	..	14·5
Total	..	100	100	100	100	100
By whom Analysed . .	..	Thomson.	Brande.	Marcet.	Proust.	Marcet.

This Table, compared with the elements of various similar substances before made prominent in this chapter and the former, affords two elucidations: one of the approximate or absolute identity of products obtained by chemists of divers nations from the same substances; and the other explaining, at one view, the changes that take place during the conversion of barley into malt, through the secret powers of germination. The comparison between unconverted hordein and the same turned into starch of malt, already appears in the former part of this chapter (page 63), the latter in the same numbers, and the former nearly so, except that Thomson has not detected the nitrogen, of which Proust gives nearly 2 *per cent.* distinct from the oxygen; and there also this kind of starch stands distinguished from that obtained from raw materials. The "gum or mucilage" here inserted does not identify itself by any means with the amidin or gum of solvent starch, as given at page 39, in any of its elements, but would

nearly resemble Guerin Varry's mucilage of linseed, were we to consider the probability of Marcet's carbon being united with nitrogen; and the coincidence may serve as a key to unlock the mystification which has confounded these two proximates in the hands of analysts. The elements of the sugar of malt are nearly as those of the sugar resulting from starch, as exposed at page 34, chap. ii., but do not, of course, agree with the principles of the cane sugar, except in the amount of hydrogen; and it is again remarkable that the above is all but identical with that obtained by Proust himself from starch and honey, which yielded exactly alike, each containing C. 36·36, O. 56·57, H. 7·07; and Saussure's analysis of sugar of grapes is C. 36·71, O. 56·51, H. 6·78; but crystallised sugar, according to Berzelius, Brunner, Proust, and Liebig, as well as Gay Lussac and Thenard, noticed before, contains from 5 to 6 *per cent.* more carbon and as much less oxygen.

In the second place, a decrease of hordein and an increase of mucilaginous gum, show how a portion of the former is converted by the maltster into the latter, through an exchange of 3 *per cent.* of carbon and about a half *per cent.* of hydrogen, for an equivalent supply of oxygen from the water or the air, that between this and starch there exists a difference of 1 *per cent.* in the hydrogen, a larger countercharge of oxygen, with very little disparity of carbon; this mucilage coming directly from the seed or its hordein, chiefly by an accession of oxygen and a loss of carbon, under new circumstances. The gluten, which appears to contain 2 *per cent.* more oxygen and less carbon than that given by Boussingault at p. 57, or by Jones from wheat at p. 46, shows a completely different arrangement of the elements, besides an appropriation of 14½ *per cent.* of nitrogen, and proves it to be altogether a different

substance from those that ran from one into another through a transmutant disposition: thus it sustains its own character throughout, though not its quantity, as it undoubtedly aids the various transitions, and helps to form the root.

These decompositions, at different stages of the process, sufficiently account for the carbonic acid gas found in the floors of the malthouse, though it is not very conspicuous there, on account of its being buoyed by the lighter elements blended with it, and kept in agitation by progressive chemical change. It is also worthy of observation, that throughout all these transformations the hydrogen and oxygen increase, and yet constantly maintain about the same proportion to each other which they hold in the formation and constitution of water, but that with mucilage it is otherwise, the hydrogen being considerably reduced; therefore, the elements of this substance are not in keeping with those stages of transition, but it is a distinct kind of matter not dependent thereon; and again, that as the carbon continues diminishing while the oxygen increases, malt sugar is an oxide of starch, and malt sugar is oxidised hordein.

Tests of Malt.—The best pure malt is light, because it has been well digested; and if the malt heap contains much rootlet or "commings," it has grown too long, and especially if the "cockspur" appears, which is, in fact, the young plumula shot through the husk at the expense of the saccharum. Equality of colour and uniformity of size are both good tokens, unless one end be friable and the other hard; for the change is progressive, beginning at the lower end of the seed, and keeping pace with the growth of the acrospire till it comes out at the top, when the whole will crumble, and all further progress robs the seed of its saccharum, and the whole

object of malting, as observed by the Scotch Commissioners, is to produce this entire change in the kernel. "It is in the power of a maltster," says a shrewd and well-informed writer on the subject, "to make the malt as unproductive as he pleases," by simply letting his grain lie on the floor a day or two longer than necessary; for if the acrospire is permitted to grow through the husk, the starchy matter undergoes a very different change from that of conversion into saccharum, for it assumes the appearance of milk, in which state it is soon sucked up by the thirsty plumula, reducing the husk to mere chaff; and hence the slightest appearance of *cockspur* indicates excessive lightness and an approach to nonentity in the malt.

A thin wiry rootlet is likewise a bad sign, and for this reason,—that in barley sown in good soils, the root is moderately short and bushy, the effort of nature being the support of the blade; but that if put to vegetate in loose or inappropriate land, the roots run out much longer, to the detriment of the plumula or stem; and from the same natural reason, if kept remaining in a loose heap on the malting-floor for any length of time, the warmth and moisture will wiredraw the rootlets very much, and thereby impede the process and impoverish the future malt. Such treatment may be a successful mode of increasing the outcast, and, consequently, the measure; but it is not the way to obtain permanent custom in the sale.

It is unnecessary to dwell upon, and almost superfluous to allude to, the demerit of malt made from barley prematurely cut or ill-harvested. It has been wisely observed, that the paltry consideration of having no other immediate work for a labourer, whose hire does not exceed twelve shillings a week, has frequently been the cause of mowing barley before its arrival at

maturity, and has ultimately, from the deficiency and inferiority of the yield, cost the employer a week's wages to cover the damage done in a few hours. The same is applicable to barleys harvested in the wet, sometimes to the value of a shilling in every five; and it is important to remark, that malt made late in the season, when the weather is becoming warm, is very inferior in its strength and constitution, from possessing lactic acid and other objectionable properties, which operate against the keeping quality of the beer, and thereby counteract its otherwise natural potency.

Another, and now very common test of the virtue of malt, but by no means novel as an experiment, is to put a handful into a glass of cold water, when the well-malted seeds swim, and will float twenty-four hours before they absorb a sufficiency of water to precipitate them; but the flints, or unmalted kernels, immediately sink to the bottom; and those partially made dip obliquely, like magnetic needles, in angles of depression that adapt themselves to the extent of their imperfection, becoming more perpendicular as they imbibe the liquid in their suspended position, till their gaseous buoyancy is overpowered by imbibition, on which they fall to the bottom after the flints and grit; and no greater proof of inequality in the perfection of the malt can be found, than in the variety of positions taken by the several corns when dropped upon the water. The sample is good when the sunk corns stand upright in the glass. After all, experienced dealers can decide at first sight; and with the eye, the teeth and palate seldom fail as tests in proving quality.

Malt newly pulverised is inflammable, and apparently electrical. The destruction of Barclay's brewhouse, London, in 1832, was caused by the accident, that a man happened to lift one of the covers upon the box

of the Jacob's ladder which conveys the malt to the hopper, and to thrust a lighted candle amongst the fine powder-like malt that was flying about when the ladder was in motion. Undoubtedly, the dry state of the grain, and its electrical condition, arising from friction in breakage between the rolls, had occasioned a state of gradual decomposition, and brought some hydrogen into the box from the vast quantity of malt that was being crushed at once, and hence its inflammability; but the danger of such an accident does not arise when the process of crushing has been ended, and the gases have been allowed to subside.

Recovering damaged Malt.—Unless malt be perfectly dried and well stored in dry rooms, secluded from atmospheric currents, it will absorb moisture, and thenceforth a decomposition of the grain, and at first of the nitrogenised parts in particular, takes place; the husk becomes tough, the farina yellow and putrid, and the released and fugitive elements impart a foul offensive odour; and it is needless to say, that such malts never produce sound beer. Broken roofs, damp walls, and bad floors, strongly tend to beget this calamitous state, and to render the health of the stock incurable; but the best curative known to the author, is to sprinkle the damaged mass with chloride of lime, blending them well together by repeatedly turning and mixing the malt well with the lime till every corn becomes enveloped within its influence, after which the whole should stand ten or twelve hours if the heap is thick, or forty-eight hours if the premises afford convenience to spread it thin. By this means the strong affinity which the lime has for water will extract it from the malt, and the noxious vapours will accompany it in its exit, at the same time neutralising the acidity and putrescence which have predominated. The malt thus

medicated must next be subjected to gentle drying on the kiln, screened twice, and brewed immediately, with two-thirds or three-fourths of a superior article; or if it is coloured brown or black for porter, that will perhaps be the best purpose to which it can be applied, since when mixed with uncorrupt malt, there is a danger of contaminating the whole mash.

Treatment of Malt.—In the introductory chapter to this treatise, page 12, among other definitions it is explained that the word *malt* is the idiomatic Saxon contraction of *malled*, signifying *bruised*. Their Roman predecessors called a broad-faced hammer or pestle *malleus*, whence the origin of *malt;* but the mill, by the Saxons called *molin*, and by their descendants *miln*, as we learn from Domesday and other ancient records, was a mere mechanical invention for crushing flour or meal, whereas the malt-mill now in use is a modern innovation, introduced for expeditious cutting into larger fractions; for if malt be ground to a fine powder, it will *set* at a lower temperature than such as is ground into bigger pieces, which opposes its parting with the water with the freedom which is requisite in order to obtain a transparent solution, and hinders at least, if it does not entirely prevent, the necessary extraction of the valuable portion of the malt. Sometimes in the application of mill-stones set for coarse grinding, the smaller corns will scarcely be touched, or only partially ground, though the larger are literally pulverised, and the husks are so minced into pieces, that the raw mealy flavour of the farina is given to the worts, which want of uniformity is particularly observable in the finer brewings for ale. Steel mills have been considered an improvement; but they sever the husks as well as the kernels, which is a highly objectionable practice; for the great object is, to have the grain so *malled* that the

liquor may have free access to every portion of the kernel, that it may extract its virtue without suffering the meal to collect into paste. With this view it is better so far to destroy the cohesion of the interior as to detach the husk from the meal without removing it, but converting it into a kind of bag or shell which shall confine the soluble farina within its own bounds, and in a subdued state, cohering, as Donovan says, "with just as much force as will prevent their falling into flour." In plain truth, the idea of a malt-roll, to obviate the evils that had arisen from fine grinding on the one hand and rough on the other, was to the doctor the *ne plus ultra* of the brewer's art, and ingenuity soon gratified his desire. By this device the husks are crushed and partially severed from the kernel; so that when the (*grist* which thou *grindest*, here it is not, but) *malted* grain is infused in water, those crushed husks become a filter, giving out only that from within, which is valuable and flows freely through. Hence the superiority of rolls to mills of any kind: indeed, they are now common in breweries, and have been found to answer in all the important points, becoming more and more efficient as talent and opportunity have improved their construction. They waste little of the farina, the expense of their repair is very trifling, the husk is not torn and rendered so frail as to fall in pieces in the mash-tun, yet the rolls (at least such as the author recommends) are sufficiently close to pulverise the whole of the saccharised contents, leaving the unconverted cuticle and less fragile portions of the farina merely split, or so dislocated as to be still held together by the integuments: thus the corn is sufficiently broken for the action of the heat and water, and of the mashing machine; but not too much so, as by the ordinary means. The goods also are light, and free from those pasty de-

positions so much to be guarded against, the large corn not being crushed too much, nor the smaller too little.

In order that the rolls may break the corn perfectly, without pulverising the husk, which is their principal utility, they should be of the same size, and travel with equal velocity; for when one is larger or swifter than the other, the unequal pressure on the corn tears the cuticle into fragments. Prior to rolling, it is expedient to introduce a wire screen, to prevent the encroachment of hard substances, and is valuable, as far as it allows the small pieces of grit, which would cut the rolls, to pass off with a considerable portion of the rootlet. Misfortunes from such a cause, whether arising from pure accident or from a mischievous disposition, are not altogether either pleasant or profitable, whether a cheek or an axle be broken, whether the whole fabric be shaken by a private jerk, or whether the driving-gear merely give way, and the cogs be stripped off a bevel-wheel.

The following Table, compiled from official information, shows the quantity, in bushels, of malt charged with duty to the British excise every ten years, from 1770 to 1820, and every year since, each twelvemonths' accounts being made up to the 5th of January. An attentive perusal of this Table will show, that, notwithstanding the great increase of consumption which took place immediately on the removal of the beer duty on the 10th of October, 1830, yet the excessive taxation to which our countrymen are still indirectly subject through the legislative impost of an enormous malt-tax, which restricts their comfort and limits the supply, keeps the consumption of malt almost stationary, not-

withstanding the immense increase of population, with which the demand for other commodities keeps pace; and another remarkable affair is, that although, within the ten years following the repeal of the beer duty, the increase in the quantity of malt consumed exceeded 25 *per cent.* of the former level, it will be perceived, on reference to the Table given at the end of chapter IX. of this volume, that the hop-duty did not rise in the same proportion, as it is to be presumed that it ought to have done, and even to have exceeded, in consequence of the great recent demand for bitter ale, particularly for the Indian possessions; an anomaly which would seem to require clearing up by the authorities who pretend to cause the statistics of the kingdom to be correctly estimated.

Ten Years ending January 5.	Number of Bushels charged duty.			
	England & Wales.	Scotland.	Ireland.	Total.
1780	249,080,233	16,872,558	....	265,952,791
1790	251,501,486	17,395,517	19,149,615	288,046,618
1800	263,528,753	17,922,597	46,026,067	327,477,417
1810	229,208,139	11,347,139	25,194,344	265,749,622
1820	230,146,858	11,117,392	22,990,122	264,254,372
In 50 years	1,223,465,469	74,655,203	113,360,148	1,411,480,820

Note.—The Irish duty commenced May 25, 1785.

Year ending January 5.	Number of Bushels charged duty.			
	England & Wales.	Scotland.	Ireland.	Total.
1821	23,884,242	1,182,208	1,793,671	26,860,121
1822	26,138,437	1,305,659	1,949,315	29,393,411
1823	26,688,512	1,403,177	1,756,391	29,848,080
1824	24,845,152	1,616,590	1,702,395	28,164,137
1825	27,615,383	2,788,608	2,107,752	32,511,743
1826	29,572,741	3,925,847	2,706,862	36,205,450
1827	27,335,971	2,726,555	2,406,252	32.468,778
1828	25,096,337	2,714,073	1,830,091	29,640,501
1829	30,517,819	3,867,159	2,409,228	36,794,206
1830	23,428,135	3,712,963	2,012,079	29,153,177
In 10 years	265,122,729	25,242,839	20,674,036	311,039,604
1831	26,900,902	4,101,946	1,959,606	32,962,454
1832	32,963,470	4,186,955	2,101,844	39,252,269
1833	31,669,771	3,714,334	2,006,350	37,390,455
1834	33,789,010	4,302,036	1,984,849	40,075,895
1835	34,449,646	4,491,292	2,204,658	41,145,596
1836	36,078,856	4,459,553	2,353,645	42,892,054
1837	37,196,997	4,903,187	2,287,535	44,387,719
1838	33,692,356	4,583,446	2,275,347	40,551,149
1839	33,823,985	4,419,141	2,262,440	40,505,566
1840	33,826,016	4,360,363	1,744,550	39,930,929
In 10 years	334,391,009	43,522,253	21,180,824	399,094,086
1841	36,653,442	4,397,304	1,406,116	42,456,862
1842	30,956,394	4,058,249	1,149,692	36,164,335
1843	30,796,262	3,786,476	1,268,656	35,851,394
1844	30,891,002	3,618,607	1,184,281	35,693,890
In 4 years	129,297,100	15,860,636	5,008,745	150,166,481

SUMMARY.

Period in which charged.	Total Bushels consumed.	Average consumption.	
		Bushels.	Quarters.
50 years, 1770 to 1820 ..	1,411,480,820	28,229,616	3,528,702
Last 10, with beer duty on	311,039,604	31,103,960	3,887,995
First 10 since do. off	399,094,086	39,909,408	4,988,676
4 years, down to 1844 ..	150,166,481	37,541,620	4,692,702
Total and average of 74 years	2,271,780,991	30,699,743	3,837,468

CHAPTER IV.

WATER.

CONFLICTING OPINIONS—HARD AND SOFT—ORGANIC MATTER—SALT IN WATER—SNOW—RAIN, SPRINGS, AND WELLS—RIVERS—THE SHANNON—WASHING AND TEA WATER—ALKALIES AND LIME—VIRTUE OF HARDNESS—BURTON—GYPSUM—FILTRATION—SUN AND AIR—ILLUSTRATIVE ANECDOTES—MINERAL WATERS—TESTS—SPECIFIC GRAVITY—LOCALITY AND TASTE.

THE subject for the brewer's consideration next in order to his malt, is the selection of his liquor, or the water in which he has now to infuse that malt for the purpose of converting both into wort; and perhaps nothing in nature varies more in its properties than this outwardly apparent simple fluid, which is not the *aqua pura* which it seems, and is vulgarly said to be, but *hydor* impregnated with a heterogeneity of earths, acids, gases, alkaline and metallic salts, and sometimes even animal and vegetable matter, some held in chemical union, and some in mechanical suspension. Pure water, or *oxide of hydrogen*, is obtainable only by art.

Brewers differ most widely in their opinions of the necessary qualities of water, some preferring hard, others soft, and others again treating the choice indifferently; in short, the stoic is contented enough to conclude that water is water, while the sceptic never considers any water good enough for his purpose, be its properties what they may.

If men would thoughtfully consider the density of their worts, and the value of cold water for refrigeration

and other useful purposes, they would not hesitate in their choice; for though a brewer already established can seldom choose his spring or his stream, the case is otherwise when the site of a new brewhouse is being selected. In adjudicating preference in brewing waters, writers have differed, the greater number being neutral, as Shannon, Donovan, Black, Combrune, and his disciple Hayman; of the soft-water advocates are Richardson, Wigney, and Roberts; and for employing hard are Levesque, Ham, and, under his own system of general management, the present author.

Ham, in venturing to disagree with the doctrines espoused by the generality of brewers, is not measured in his terms, and his reason is powerfully substantial. "We feel a diffidence," says he, "in being obliged in some degree to dissent from received opinions on the qualities of this menstruum, when applied to brewing. There are two methods of producing the higher qualities of beer, the slow and the expeditious; the former in country places principally, and the latter in larger breweries of cities and towns, where the adoption of the plan of producing early ripeness by hastening the fermentation is become common, to the impoverishment of the national beverage; and the distinguishing marks of the superiority of the British brewery to all others are now nearly lost. We would therefore wish, if possible, to see it brought back in some measure to its original excellence, not by increasing the quantity of materials used, but by making the most of them in conducting the fermentation much more slowly than it is at present the custom to do. For this purpose we most decidedly prefer hard spring water, particularly that from wells dug in a chalk soil, where it can be obtained. . . . . We can now oblige the hardest water to make an extract from the malt in equal quantity, if necessary, to that

produced by rain or snow-water, possessing, besides, the valuable property of checking the fermentative process. To those, therefore, who still wish to hasten that process, so as to anticipate age, to the impoverishment of the liquor, we would by no means recommend the use of hard-water, for if the fermentation is to be conducted with expedition, hard-water will be found inimical to its progress; but in all other cases, where a fulness of the palate is sought to be preserved after keeping the beer a considerable length of time, we invariably approve of the hardest and most transparent water that can be procured." (p. 31.) This is sensible language, and so far explanatory of the grand *ultimatum*, that it becomes the very motive by which the author of the present treatise is actuated, and the principle to which his system is peculiarly adapted throughout its several stages.

Water that is free from saline matter, or that holds it in scarcity, is not fit for the brewery, being impotent. The softest is in the state of snow, which, according to Bergman, is destitute of all gaseous bodies, so that fish, as announced in the Journal de Physique by Carradori, cannot live in it, because it has no function; whereas good water, which, according to Thomson, is entirely colourless and as transparent as crystal, contains 1 *per cent.* of carbonic gas, with other ingredients, such as silica, oxygen gas, salt, muriate of lime, sulphate of potash, and the carbonates of lime and soda, all of which were discovered by Bergman in the springs round Upsala, which are considered to be exceedingly pure; but rain or soft-water does not contain carbonate of soda, sulphate of potash, or silica; and it has been observed by Morveau, that rain-water which drops from the roofs of houses, after the rain has continued awhile, contains only a little sulphate of lime, which it has

dissolved by trickling down the slates. As for the muriate of lime which rain can contain, it must, according to the same learned philosopher, be exceedingly small.

The next gradation is into springs: these are no other than rain-water which gradually filters through the earth, and by collecting at the feet of declivities, forms fountains and channels, and comes out at the surface. From this circumstance it is as pure as rain-water, unless it have met with some soluble substance in passing through the soil, and become impregnate with it. Various streams may thus be formed, and flow in sundry directions, according to the internal stratification of the land, and with variable acquisition accordingly; which accounts for the fact that soft and hard springs are often found close to each other; but it is generally found that in the purest of springs some little carbonate of lime and common salt are found, besides the usual quantity of air and of carbonic acid gas, with sometimes muriate of lime, carbonate of soda, or both. In 100 cubic inches of water, from which Dr. Henry expelled the air by boiling, he found 4·76 inches of incorporated gas, of which 3·38 inches were carbonic acid, and the remaining 1·38 atmospheric air.

Well-water is the same as spring-water, because it comes from the same source; a well being a cavity to receive the contents of one spring or channel, or perhaps more; but as its waters do not pass away, as in the case of an ordinary spring, it is more likely to receive an accumulation of foreign matter, till by repeated deposition and by stagnation it becomes *hard;* that is, till the quantity of earthy salts held in solution by it, will not allow it to dissolve soap.

River waters are a collection of rain and springs, fluctuating with the seasons, but usually possessing

greater softness than springs, both from admixture with rain and snow, and from their depositing the matter mechanically suspended, as they proceed in their course, retaining only the usual extraneities that are in chemical union, as air and carbonic-acid gas, with a very little salt and carbonate of lime. That the quantity of this kind of water is variable according to season and geological construction, might be analogically inferred from the natural realities that heavy and continued rains penetrate farther into the earth, and urge their course by greater pressure than ordinary wet, each stratum in the road of descent furnishing pregnable matter different from that above it. But the chemist goes beyond this in his views, and gives demonstrative proof of the facts; for instance:—

Thus, Mr. St. Pierre Foley, Lecturer on Chemistry and Geology at Limerick, in three experiments on the water of the Shannon, undertaken under different states of the contents, in March, 1842, has produced the following as the fruits of his analyses, an imperial pint being his integer:—

I. As passing from the river up a pump, in its usual state.

	GRAINS.
Carbonate of lime . .	5·95
Sulphate of lime . . .	0·62
Sulphate of soda . .	0·30
Chloride of soda . . .	1·97
Magnesia, carbonated	0·25
Dead organic matter	2·10
Total grains	11·19

2·62 grains of carbonic-acid in addition, hold the 5·95 of carbonate of lime in solution; therefore, there are in every pint of such water 8·57 grains of bicarbonate of lime.

II. The same filtered and tested afterwards.

	GRAINS.	
Carbonate of lime . .	5·55	The 5·55 grains of carbonate of lime were again held in solution by 2·62 grains of carbonic-acid, making together 8·17 grains of bicarbonate of lime to the imperial pint.
Sulphate of lime . . .	0·60	
Sulphate of soda . .	0·30	
Chloride of soda . . .	1·97	
Magnesia	0·20	
Vegetable and animal matter	0·02	
Total grains	8·64	

III. Taken up in a flood and unfiltered.

	GRAINS.	
Carbonate of lime . .	5·9	The carbonate of lime is not increased, nor does there any appear in addition, that the filter will not remove.
Sulphates	1·0	
Muriate of soda and earthy matter . . .	7·0	
Vegetable matter . . .	2·0	
Total grains	15·9	

To this the analyst adds: "I think it right to remark, that on a hasty analysis of the Shannon water, made about the latter end of September, 1841, I then found that the water contained much more chloride of soda than at present, and somewhat more organic matter, but the proportion of lime seems constant."

From the above results Mr. Foley deduces these conclusions:—

1. That by a series of tests similar to those by which he discovered the presence of the enumerated properties, he proved the absence of others, such as all nitrates, free alkalies, alumina, potassa, iodine, and silica.

2. The hardness of the water for economical purposes, established by the excess of lime held in solution by the carbonic and sulphuric acids.

3. The great advantage of the filter in removing the whole of the mechanical mixtures thrown in by the floods, and almost all the vegetable and animal matter.

4. The non-removal of the lime by filtration, through its being held in chemical solution, chiefly by an excess of carbonic-acid: this he looks upon as the chief "*bane*" of the water; but though he has encountered "Father Shannon," he is not bound to be a brewer.

5. That the lime must, nevertheless, be removed, ere the water can be fit for those domestic purposes in which soft water is effectual; and to accomplish that object he recommends Professor Clark's process, and concludes by urging the necessity of purification.

The following analysis of a spring which supplies an eminent brewery in Kent, and of a well which they have upon the premises, but from which they never brew, shows the great dissimilarity of waters in the same locality, and the necessity of good judgment in giving preference. The quantity in each case was a gallon.

The Spring.	GRAINS.
Chloride of calcium (muriate of lime) . . .	6·043
Sulphate of lime (gypsum)	5·210
Carbonate of lime (chalk)	18·160
Carbonate of magnesia	0·150
Nitrate of soda, by estimate	6·476
Total contents	36·039

The Well.

	GRAINS.
Chloride of sodium (common salt)	50·085
Sulphate of soda (Glauber salt)	2·124
Carbonate of soda	17·200
Carbonate of lime (chalk)	5·760
Carbonate of magnesia, no sensible weight.	
Total contents	75·169

The well-water, which comes from a bed of blue clay, though as clear as that of the spring, is rather unpleasant to the taste, as might be expected; and surely no uncommon sagacity can be needed to ascertain which of the two best suits the brewer in the exercise of his profession.

Depositions may be found adhering to a tea-kettle, or other vessel in which hard water has been boiled, and serve to purify rather than strengthen the water. Every thrifty housewife knows that carbonate of soda, or that pearlash, which is a subcarbonate of potash, will expedite the process of making tea, and will assist her in the washing operation; and she knows practically that snow will have the effect of softening hard water. The effect of alkalies is to precipitate the earthy substances; but by the addition of snow the water is merely diluted, and the same quantity of foreign matter is diffused through a greater bulk of water; but the lime which hard water holds in solution, by its action upon the soap decomposes it, and thus renders the water unfit for the washerwoman's use. Rain water contains about 2½ *per cent.* of atmospheric air, and the gaseous bodies composing it are set at liberty by the boiling of the water, and the solid substances are deposited, forming the thick incrustations that line the kettle.

Carbonate of lime is but sparingly solved by pure water; but when carbonic acid is present, as in the case of the Shannon, the solution and retention are more effectually and permanently secured; and this is another argument for not heating the water in the brewery so that it shall expel the property that holds it in existence there; and moreover the disposition is increased when the carbonate comes in contact with the sugar of the malt, and, of course, afterwards in the ale, where an additional portion of carbonic acid is generated by fermentation; for sugar is a powerful solvent of lime. Dalton asserts, from the results of his own experiments, that the hardest spring-water seldom contains in solution so much as one-thousandth of its weight of any foreign body; and it appears from Foley that the filtered Shannon contains one in nearly 1012: since, however, the fact is admitted that sulphate of lime, gypsum, selenite, or be it called by what synonymous term it may, is the constituent that makes water hard; and since the sulphuric acid, which is its essence, probably corrodes the gluten, albumen, &c., and renders their powers inert in their decay, its good qualities must at once be acknowledged by the brewer; but it cannot be everywhere obtained; so that it would be well to consult some able chemist on the readiest and cheapest mode of impregnating certain waters artificially with such properties as are desirable.

The sulphate of lime is found as a mineral in great abundance at Chelaston, near Derby, and at Beacon Hill, near Warwick; it is also procured in large quantities from North America, and has become greatly esteemed as a manure. The anhydrate of Werner contains a still larger portion of sulphuric acid; as a specimen analysed by Klaproth, was found to consist of

sulphuric acid 56·5, lime 42·0, muriate of soda 0·25, loss 1·25; total, 100.

Has, then, the use of hard water no good effect in the management of the brewery? The author knows, from his own experience, that worts made from water of this kind, require pitching from ten to fifteen degrees higher than those from the very pure waters, in order that the same attenuation may be effected in the same time; and hence their preservative property; but there is, besides, another advantage in the use of hard water, which is, that more saccharine matter can be left in the article, by which the fulness and flavour will be greater, without the risk of becoming acid, as other full-bodied ales do, especially in hot weather.

The Burton ales principally owe their superior qualities and uniform permanency to the nature of the water there used, and which, according to the best evidence, is strongly impregnated with this hardener of water, gypsum or sulphate of lime; the principal geological feature of the place and environs being described as a tolerably perfect gypsum, occasionally interspersed with carbonates.

When Booth, or rather his employers, the "Society for the Diffusion of Useful Knowledge," first brought out their Treatise on the Art of Brewing, some reflections there cast upon the Burton brewers induced them to stand forward in a body, and to commence legal proceedings against the publishers, Baldwin and Cradock; and the cause was brought before the Court of King's Bench on the 10th of May, 1830, when Mr. (now Lord) Brougham stated that chemists of eminence had been sent down to Burton to analyse the worts and the waters, and that the Committee of the Society were satisfied with the honesty of the brewers, who had

thrown open their doors to receive the analysts; but he added, that "the learned person, the author of the treatise in question, who was a practical man, being a brewer of twenty years' standing, had been misled upon the subject, by circumstances which might have misled any body. He had said that he could make Burton ale, similar to that of these brewers, if he were allowed to add certain saline impregnations, chiefly gypsum. Now it so happened, though the fact was not known to the author at the time the treatise was written, that the springs at Burton ran over a rock of that substance, which gave them a natural impregnation." Under these circumstances, the learned counsel admitted, on the part of the Committee, that nothing deleterious was used in the Burton breweries; and the rule for a criminal information was discharged, upon the condition claimed by Mr. (since also created Lord) Campbell, that the contradiction should be as extensively circulated as the libel had been. "Very well," said Lord Tenterden, who presided, "the lovers of Burton ale may now drink it without fear;" to which Mr. Brougham responded, "If they drink it in moderation." The above apology or explanation was to appear in the future editions of the work; and in an ungracious accordance with the covenant and decree, the following appears in the 52nd page of the second edition, published in 1834:—

"One of the affidavits gratuitously acknowledged the occasional use of flour and salt, to assist the fermentation of the inferior ale; and the jalap, of which it only was said that 'some recommend' for the same purpose, (and the use of which is doubted at page 28, part I.) may as well be left out of the supposed accusatory list of ingredients. These, then, are reduced to salt of steel, 2 ounces to 20 barrels; honey, 1 lb. *per* barrel; sulphate of lime, 6 ounces *per* barrel; and black resin,

1 ounce *per* barrel." Thus stands the notable attack on that communicative, and, as Lord Brougham called them, "generally respectable" body, the brewers of Burton-on-Trent, whose chief excellence lies in sulphate of lime; and yet men will decry hard water, as though it were a detriment and plague, though one ounce of that which makes it so will preserve six gallons of ale "for ever and a day." But David Booth preferred, like Naaman, or rather Combrune, "Abana and Pharpar, rivers of Damascus, to the waters of Israel;" and, like Gehazi, was subjected to leprosy in consequence.

The author, unwilling that his judgment should be circumstantially dependent, has made inquiries on the spot, and is obliged to the politeness of Messrs. Bass, Ratcliffe, and Gretton, the eminent Burton brewers, for the following information on Burton water.

"The wells in Burton, used by the brewers, are from twenty to twenty-four feet deep, and are supplied by springs which enter them on the opposite side to that on which the Trent runs.

"Some years ago, Mr. Cooper, of London, analysed some water taken from the well at our brewery, the result of which was as follows:—the imperial gallon contained of uncombined carbonic acid, 7·5 cubic inches. Its specific gravity was 1·0013, and the solid contents obtained by evaporation 79 grains: those solid contents were composed of—

Carbonate of lime	9·93
Sulphate of lime	54·40
Muriate of lime	13·28
Sulphate of magnesia	0·83
	78·44

"The water used by Burton brewers is not exposed

to sun and air: it is generally pumped direct from the well to the copper. There are not more than two or three reservoirs in the town, one of which is on our premises, and is under a roof. It is certainly not used for the purpose of exposing water to the sun and air. (In reference to this, see forward, p. 122-3.)

"As to the locality of Burton, it is certainly favourably situated for brewing, on account of its abundant supply of peculiar and excellent water for the purpose; and in that respect it would, perhaps, be very difficult to find a place equal to it."

On this information only one conclusion can be formed, which is, that an indifference to the quality of the water is equivalent to a carelessness of the fate of the wort, and that Burton water contains special virtues not to be found in soft. It appears that Burton water is 9 *per cent.* harder than the Shannon, the incorporated matter being one grain in each 892.

Sulphuric acid will undoubtedly prevent a secondary and acetous fermentation when a small quantity of this acid, or muriatic acid with alum, is added to malt liquors; and it does this in one or both of two ways, namely, absorbing all the superfluous oxygen present, instead of allowing it to attack the alcohol; or acting caustically upon the albumen and gluten, and rendering them insoluble as the mixture increases in density, and precipitates them to the bottom: hence the desirable properties of the limestone are attributable to its acid; and if this idea is correct, the attributes belong to the sulphate, and not to the carbonate; nor has it been shown that carbonic acid will accomplish much of this. Chemical practice determines, too, that carbonate of lime is generally accompanied by a sulphate or a muriate, either of potassa, or of soda, or of magnesia, or of lime, and often by both of those kinds

of salts, as at Burton, and in the swollen Shannon after a flood.

Water highly impregnated with gypsum, is much harder than that containing carbonate of lime, and for reasons already advanced, though the quantity of each be the same; and this difference is to be attributed rather to acids than to the alkalies or the like. When waters run off moors and fens, and the brewers in certain districts are compelled to use them for want of better, it will be found desirable to impregnate them at second hand with gypsum, or with such limestones as are easily procurable. If calcined, their solution by the water is thereby facilitated, but the operation expels a portion of the sulphuric, carbonic, or other acid, and of the water combined with the lime, but not without some deterioration of their anti-acid virtue; and they form hydrates, and afterwards become carbonates, by re-absorbing the carbonic acid of the liquid which they were intended to improve and preserve. Where the burnt mineral is obtainable in great plenty, the loss of disengaged sulphuric acid may be compensated by employing a superfluity; but it is much better to use it in the primitive state, giving more time for gradual solution, as in the Burton and Chelaston soil.

FILTRATION OF WATER.—As it is really necessary that all waters, whether fluent or stagnant, should be purified from the substances mechanically suspended within them, which can be done by plain mechanical means, many machines and other devices have been brought to operate with that intent, and nearly a hundred patents, or perhaps more, have succeeded each other in this and other countries, all intended as improvements upon plans then in operation, or as substitutes for such as were found defective or otherwise objectionable; and of those that have been found least so, the author has pre-

ferred and recommended spacious beds of antiseptic and anti-acid substances, such as calcined bones, vegetable charcoal, or limestone in the sulphate or carbonate state, or the nearest approximates, laid in strata, the coarsest uppermost; prior to which he would introduce a filter of sand to avoid choking in the finally corrective filter, which sand might be changed as it became foul or did not work well; but in a "Memoir on the Filtration of Water on a large scale, and on the Properties of Maurras's Patent Filter," recently addressed to the Commissioners for inquiring into the health of towns, by B. G. Sloper, Esq., he at once recognises a system calculated, for the present at least, to eclipse all others in efficacy, simplicity, and economy; and as the machines may be constructed in number and magnitude according to the quantity of water in requisition, they certainly can be recommended to the trade, with the few following remarks, taken from the Memoir.

1. In all artificial filters, the filtering material should be unexceptionable. It is not sufficient only that it should be porous, but its chemical nature should be such that it cannot change under long continued moisture, decompose, ferment, or by mechanical rupture, allow particles of its substance to pass away at any time with the filtered water.

2. Regard should be had, before we sink our shafts, run our tunnels in sand and rock, construct artificial sand filters of large dimensions, or manufacture our machines, 1st, to the first cost; 2ndly, to the cost of filtration; and, 3dly, to the durability of the filter.

3. One of the most essential requisites of a system of filtration is its certainty and permanency, as well as the means of extending the product of filtered water with the increased wants of a population, without the chance of diminution or failure from any cause whatever.

Mr. Sloper, after examining a variety of systems, including all those that are or have been the most popular, and pointing out the defects of each, observes that, as in one of Wickstead's artificial sand filters, which yielded at a rate noted 10 the first week, 9 the second, 6 the third, and only 2 the fourth; so a large *natural* filter may render an abundance of water for a number of years, and after a time surprise the engineer by the rapid decrease of its product, and possibly its ultimate total obstruction. Acting, therefore, upon the principle that all vegetable and animal filters, such as those of cotton, wool, charred wood, bones, &c., which last, with others, (like the public filter of the Garonne at Thoulouse, which has cost £40,000 to supply 50,000 inhabitants, or 16*s.* a head,) he proves to be excessively dear; and that water filtered even through sand deposits its solid impurities, to a certain depth, between the interstices, till that which at first was a porous filter becomes an impermeable earthy mass, feeding vegetation rather than purifying water, he says, with true resolution, that "*if nature does not renew the filtering surface,* MAN MUST;" and thereon he founds the credit due to Maurras for his invention, which has contrived "that the filtering material is sand of various degrees of fineness, so arranged that it cannot escape from its position in the machine, and that the dirt is effectually removed at intervals, and the porosity of the filtering sand restored." Besides this, it is "applicable to small communities as well as the largest, possessing ALL the qualities required for a permanent constant filtration, *viz.* uniform and unvarying porosity, durability, a constantly pure and unfermentable filtering medium, certainty of product, and moderate cost."

A particular description of this novel machine, with a drawing, is given in the Mechanics' Magazine, Vol.

XLI. p. 152, where he explains that with a surface of 5½ feet square, (doubled, of course, that one may relieve the other, as he says 60 feet in all,) he can clear 150,000 gallons in 24 hours, with a head of water 26 feet. The whole machinery he declares to be almost indestructible, and the porosity of the filtering sand not to vary, being riddled and placed according to sizes. The New River Company in London have tried the experiment for four months on this scale, and certify that with 12½ feet head of water it discharges 118¾ gallons in 10 minutes before cleansing, and in 7 after, or in 8½ on the average, which is 20,118 gallons a day, or 665 to each foot of the filtering surface.

Still, notwithstanding the excellency of this invention, which professes to purify the supply of water to a poor man's cottage for twopence or threepence a year, no filter, however ingeniously constructed, can sweeten tetric water when its tetricity has passed from suspension to combination; nor will any other means yet known, including evaporation, do it on a scale suitable to brewing. If communities will inhabit places which will not naturally supply their proper wants, particularly for this purpose, and if they are too poor or too idle to obtain a purer beverage by artificial means, they had better import their beer from localities that can produce it in perfection. Waters brought from a distance across the country in open aqueducts, are often so surcharged with decomposed vegetables and ordure, and have lost so much of their better qualities by evaporation, that they stink within a few hours after coming upon the premises; and even when not precisely so, passing all that distance in subjection to the sun's rays in the summer months, warms them till they reach 60° or sometimes 70°, which renders them completely useless as a cooling medium. It is surely enough to repeat

that such places had better have their beer brought to them than their brewing water, and thereby burst the wretched trammels which monopoly, nature, and custom, compel them submissively to wear, to the destruction of their health, their capital, and their comfort.

Gypsum, which according to Ure is 2·2 in specific gravity, or nearly the same as the carbonate, is constituted of 28 parts lime, 40 sulphuric acid, and 18 water, and which are the weights of its prime equivalents, shall now be considered in a way that cannot reasonably fail to create alarm in the mind of the careless but sensitive brewer. The author having in his experience tried all sorts of water, from the hardest to that which is called the purest, and never having failed to obtain as good an extract from the former as from the latter, is sure that the principal objection to the hard is founded on the old erroneous notion of its want of capability in extractive power; he is therefore persuaded that nothing but a correct knowledge of the art of mashing, and a little patience in attending to the fermentation, can be wanting to bring it into general repute: this theory has so often been practically proved of late, that nothing but the confirmed bigotry of senseless custom can oppose it. Should any further arguments be necessary, the following surely will suffice:—A near relation of his was, a few years since, connected with two breweries in the same town, only a few yards asunder, and supplied with water from the same stream, which water was notoriously hard. In one of these breweries, the copper was commanded by a very large and flat liquor-back, which was exposed to the sky for the purpose of rendering the water softer, previously to being used in the mash-tun; and precipitation and evaporation, of course, did their part in effecting that change, and in proportion to the time that the water lay in its tranquillity.

The other brewery had no liquor-back, but was provided with a good dome copper, the pan of which received the water as it was pumped up from the stream. The two establishments were just at par in regard to strength, price of materials, connections, plant, and management, except as above described; but the truth was notorious, that during the summer months the ale brewed from the water which had been deprived of a part of its saline contents by exposure to the air, would not keep so well as that made at the other house: indeed, a sour article was scarcely known in the latter brewery, nor were finings ever used or needed. In another house at some distance from these, an event, sufficient to satisfy all reflecting men, came beneath the author's own personal observation:—This brewery was situated on a limestone rock, from which issued a beautiful stream of hard water; and this was uniformly used in the brewery with invariable and complete success, until a change took place in the practical department, through the introduction of a "clever young man" from a soft-water country, who took the reins, and being an adept in art and mystery, very skilfully and chemically softened all his water prior to using it, by adding sub-carbonate of potassa and some other alkaline extract of grave and serious importance. All this in cold weather went on smoothly enough; but lo! summer came, and brought the brewer's sour foe; and our clever young operator, who was to have shone as a paragon among the brethren, was obliged to learn that he had disengaged the sulphuric acid, and deposited the lime, by a misapplication of potash; and that while he had smarted under the extreme mortification of seeing nearly as much sour ale brought home as had been sent out to the consumers, he attributed his disastrous fortune to the original nature of the water instead of himself!

The author one day, when expatiating on the virtue of hard water, was asked by a gentleman rather largely connected with a brewing-house, "Admitting that carbonate of lime is indigenous to grain grown upon gypsum or other limestone, and is desirable in malt liquors, why not put it in the water or the mash?" His reply to the question was and is, that the more gradual the impregnation, the more minute and copious are the particles imbibed, and the more permanent are their existence and hold; for as it filters through the soil, it dissolves a portion of the soluble salts with which it comes in contact, either by its own solvent power, or by the action of the carbonic acid it contains, whether native or incident. The same will apply to the grain grown upon alkaline earths, with these additions, that the alkali impedes the formation of an acid such as is generated during the ripening of the corn, and the existence of which is natural, more or less, in all grain; and besides this, the particles of the alkali are of the finest and most soluble description, being macerated, filtered, and literally grown in and with the farina of the grain, as its vegetation advances; and when thus imbedded in the corn, it is still more minute and more intimately blended throughout its parts, being aided by the best means, namely, the solvent powers of the native sugar of the barley when in a green state, and particularly just before ripening. This favourite mineral water of ours is more efficient to the brewer as an anti-acid, than mineral corn, the quantity of the essential properties possessed by each, being vastly different in proportion to the bulk: the advantage is in each case, however, decidedly great, whether they be taken separately or connectedly; and in the common system of brewing, both are highly desirable when attainable, let the haters of hard water declaim as they are wont.

While treating of mineral waters, the author must not forget that he is addressing his observations to a brewing portion of the world, or to such as wish to be conversant with that art, and would therefore be particular in recommending such as are invaluable to brewers especially, some of which may be unfit for the majority of manufactures and domestic uses; while, on the other hand, some waters which those classes of persons employ, are not of fit quality to be introduced into the brewery. Water, for instance, that contains such large quantities of salts and such a variety of gases as are usually found in the medicinal fountains of our fashionable spas, are often unfit to be taken into the brewery, on account of their purgative or other peculiar properties; yet many of the inhabitants employ them for their regular common domestic purposes, some of the saline and gaseous properties from which they derive their medicinal celebrity by operating on invalids, being removed by a little exposure to the atmosphere; or it may be that the water does not materially affect the healthy and constitutionally strong, in whom custom has established the prerogative of second nature. However this may be, the object now sought is not to cure, but to prevent sickness; and it has been shewn that at least some hard waters can be used in the brewery with considerable advantage.

Chemists divide mineral waters into four classes, namely, the acidulous, the chalybeate, the hepatic or sulphurous, and the saline; the first of which, though generally containing earthy carbonates, have an acid taste; the second are replete with iron; the third, by their sulphur, present an obstacle to fermentation; but the fourth sometimes possess all the necessary qualifications by containing salts whose base is lime, and generally the carbonate or the sulphate, or perhaps

both, while others have an alkaline or magnesian base; the latter of which are purgative and bitter.

Leamington water contains 150 times as much of the sulphate of lime as of the carbonate, and nearly four times as much muriate of soda as of both, the whole of these constituting about one-fourth of its whole quantity; and Dr. Garnet has not shewn that Harrowgate water contains any sulphate of lime, or more than $\frac{1}{3600}$th part of the carbonate; so that the public have little need to fear that brewers will purge them with such as are denominated medicinal waters: their medicine is not water, but sweets and bitters.

Some waters possess all the properties that are serviceable in the brewery, and yet, like these, are unfit for use in consequence of something inimical which they also possess, as in the following specimen, taken from a spring near Shooter's Hill, in Kent, one quart of which on analysing gave these very important constituents in various states of combination, amounting in all to 151 grains:—Sulphate of magnesia (Epsom salts), 88; muriate of magnesia, 10; muriate of soda (culinary salt), 32; sulphate of lime, 8; carbonate of lime, 10; and argil or common clay, with a little calx of iron, both diffused but not dissolved, 3. This result must surely at once point out the necessity of examining all waters before they are brought within the precincts of the brewery; for notwithstanding that water is the brewer's most important compound, little attention has been paid to its latent properties, except where its effects have been so striking as to produce an extreme of good or harm. According to Cavendish's original tests, the composition of pure, tasteless, and transparent water, is H. 11·1, O. 88·9; but later and more refined experiments give H. 15, O. 85. In all probability water was never found perfectly colourless when in a mineral

state, but with a yellow, blue, or green tinge, according to the properties of the vegetable, animal, or mineral matter held in solution, or being in contiguity to it; and some ascribe its shades of colour to optical causes or illusions not clearly understood. The waters generally called hard, however, in which soap will fall into flakes resembling snow, in consequence of a superabundance of alkaline, metallic, and earthy salts that they contain, and are rendered turgid by a solution of gold in *aqua regia*, or of silver in mercury, or of lead in nitric acid, or acetate of that metal, may be tested by any of these several means; and the difference in water generally may be discovered by appropriate tests, for which purposes a long list of the substances found in mineral waters, and of the re-agents employed to detect them, is given in Carey's "Chemistry as it was, compared with what it is," but nothing completely definite can be achieved without recourse to analysis, which was long considered a difficult process. Experimenters will now find a code of rules, and a description of the requisite apparatus in Kirwan's "Essay on the Analysis of Mineral Waters," and in the "Annals of Philosophy" as communicated by Dr. Ure. The following, with the tests applied to each, are from Carey, and are simple and useful:—

Acids in general; discoverable by infusion of litmus.

Acid, boracic; by acetate of lead.

Acid, carbonic; by litmus, lime-water, or barytic water.

Acid, muriatic; by nitrate of silver or of lead.

Acid, phosphoric; by solutions of barytes, or nitrate of mercury.

Acid, sulphuric; by barytic salts, pure barytes, or acetate of lead.

Acid, sulphurous; by its smell and its effect on black oxide of manganese, the colour of which it changes.

Alkalies in general; by vegetable colours or muriate of lime.

Alumine; dissolved by acids, succinates.

Ammonia; by its smell, or by nitrate of mercury.

Carbonates in general; by effervescence on adding acids.

Earths; by precipitation on boiling them, or by an alkali.

Hydro-sulphuret of lime; by sulphuric or nitrous acid.

Iron; by the same tests. The sulphuric acid dissolves it.

Lime, pure; by water saturated with carbonic acid.

Lime, dissolved; by oxalate of ammonia, or barytic solutions.

Magnesia; by precipitation on boiling, if dissolved by carbonic acid and pure ammonia; or the phosphate of soda, when by other acids than the carbonic.

Muriates of alkalies; by solutions of silver.

Muriate of lime; by the same, or by oxalic acid or oxalic ammonia.

Sulphates in general; by barytic solutions or acetate of lead.

Sulphate of ammonia; by barytic solutions or by boiling with fixed alkalies, which dissolve it.

Sulphate of lime; by barytic solutions, oxalic acid, or oxalates.

Sulphuret of alkalies; by polished metals or nitrous acid, or by their smell when sulphuric or muriatic acid is put to them.

Sulphuretted hydrogen gas; by its smell, or by acetate of lead, polished metals, or infusion of litmus.

The following are St. Pierre Foley's notes on his analysis of the Shannon water, made for M. Fitt, Esq., Newgate Brewery, Limerick.

TESTS USED.	RESULTS.
1. Aqua ammonia	*No precipitate.*
2. Turmeric paper when cold . .	*Air bubbles, but no change of colour.*
3. After boiling some time . . .	*Brownish.*
4. Acetate of lead	*Very dense.*
5. Muriate of barytes	*The same.*
6. Nitrate of silver	*The same.*
Do. do. by light	*Purple and blackish.*
7. Oxalic acid	*Slight.*
8. Oxalate of ammonia	*Dense.*
9. No. 1 after the carbonic and sulphuric acids were removed	*Cloudy.*
10. Lime-water, after removing the sulphates of earthy matter, by evaporation, oxalic acid, and alcohol	*Cloudy.*
11. No. 6. Precipitates dissolved in alcohol, and evaporated to dryness	*Effloresced.*
12. Sulphates and nitrates removed, then test No. 6 . . .	*Very brown.*
13. Tincture of galls	*No precipitate.*
14. After removing sulphates, add No. 8	*Extremely dense.*
15. No. 10, acetate of barytes, filter, evaporate, digest in alcohol, and evaporate to dryness	*Efflorescent.*
16. Prussiate of potassa	*No change.*
17. Phosphate of soda	*Slight.*
18. Ditto and ammonia	*Dense.*
19. Saturated solution of soap . .	*Very curdy.*
20. Ditto half saturated	*Curdy.*
21. Ditto saturated an eighth . .	*Ditto, slightly.*

TESTS USED.	RESULTS.
22. After boiling and filtering, add No. 8	*Cloudy.*
23. Starch, &c.	*No change.*
24. Sulphate of zinc	*Trace.*
25. Sesqui-carbonate of potassa .	*Trace.*
26. The same shaken and let rest for 24 hours	*Cloudy.*

The same results are observed in the water passing up the pump and that after the filtration, except in No. 12, with which no colour appears in the filtered water: the results and non-results therefore are:

RESULTS.	NON-RESULTS.
1. Bicarbonate of lime.	1. No nitrates.
2. Sulphate of lime.	2. No iron.
3. Magnesia.	3. No alumina, except after flood.
4. Muriate of soda.	4. No free alkalies.
5. Sulphate of soda.	5. No iodine.
6. Dead organic matter, vegetable, animal, &c.	6. No free acids.

Such are some of the means to which others as well as the author have resorted in order to discover the quality of water; and he can with truth add, that there are few specimens in which some of these symptoms do not appear. As a general rule for discovering the extent to which any particular supply of water has imbibed foreign impregnations of a saline or other mineral character, the specific gravity of distilled water, which is equivalent to a cubic foot, is 1000 ounces; this is made a standard of weight, and kept as the criterion of specific gravity where substances have to be compared, throughout the world of science and of commerce; and is the

foundation on which all measures of bulk, hydrometers, and other statical instruments, are based. Water from the same stream, and sometimes from the same fountain, is often, from the causes that have been assigned, found to vary in its specific gravity, and thereby to indicate a variableness of density, being at its *maximum* on the commencement of a flood, and at its *minimum* soon after such flood becomes slow and limpid; but these changes are seldom so far perceptible in the majority of spring and mineral waters, as to allow the brewers who use them to calculate upon them with any degree of certainty. The acids are weightier than water, and so is lime; therefore each of these will increase the specific gravity of the liquid in which it is mixed, in proportion to the quantity of the mineral present; though a question may arise as to which of these takes the greatest part in adding to the density of the water; but upon making comparisons, we shall find that which contains the most acid, and especially the sulphuric, to be not only the hardest, but also the heaviest; the increase of density and gravity depending in some degree on the principle of condensation, so apparent on the admixture of the acid with water in the ordinary way. Scudamore, in his "Chemical and Medical Report of the Properties of Mineral Waters," page 2, copies Kirwan's work on this subject, where he gives the following formula for estimating the quantity of solid matter from the specific gravity, which, he says, will give the true proportion within 1 or 2 *per cent.*:—"Deduct 1000 from the specific gravity of the water, and multiply the difference by 1·4; the product will represent the quantity of solid contents. It gives the weight of the salts in their desiccated state, and consequently freed from the water of their crystallisation. The weight of the fixed air must be also

included. *Example:*—Let the specific gravity of the mineral water be 1079 and that of distilled water 1000; $(1079-1000) \times 1{\cdot}4 = 110{\cdot}6$; or 1000 parts of water of that specific gravity should, according to Kirwan's rule, contain 110·6 parts of saline water. He adds, that Brisson found a solution of two ounces of salt in sixteen of water to have its specific gravity 1079: here eighteen ounces of the solution held two of salt. Now, as 18 : 2 :: 1000 : 111·1."

In consequence of the indifference manifested towards the subject of water by a certain class of writers, and of the acerbity evinced by some brewers, and the nescience of others, especially in handling the waters termed hard, the author has opened his thoughts and spread their contents more diffusely than every-day affairs could have justified,—being convinced that not all practical men have time to bestow upon recreative reading, though it be instructive; if, however, the arguments and proofs which he has adduced are calculated to awaken the understanding incidental to men of common sense and prudence, which has been his aim and wish, he has his reward in the conviction.

Men are too apt to think of others only in comparison with themselves, as though all were surrounded by like circumstances, which may account not only for the disparity of judgment between Booth and the Burton brewers, and our "clever young man" and his customers, but likewise for the failures of many others whom shame or policy has withheld from publicity.

The localised brewer, who is unacquainted with the public taste abroad, seeing as through spectacles made to suit his own eyes and age, is ready to attribute other men's misfortunes to unskilfulness or neglect, and hesitates not to suggest or dictate such antidotes as are reasonable to his own thought, though others can see

that nothing could be more erroneous if made general. How different, for instance, is the ale brewed in Scotland from that produced in the South and West of England! Who is there in Britain that cannot discover a difference of flavour and gust between the London and Dublin porter? Who that has travelled would expect to find the London taste in Newcastle ale, or either of these in the ales prepared at Liverpool, Lincoln, Nottingham, Sheffield, Birmingham, Derby, the Staffordshire Potteries, Maidstone, Dorchester, Devonport, Alton, or North or South Wales? The eighty-seven brewers of Manchester supply as many varieties of flavour and excellence, but still it is all Manchester ale. Each respective article in any of these places, if of good quality, is preferred by the local consumers of "the cheer" generally, to every other that in their opinion can be brewed. The inhabitants of the towns and villages "round the Wrekin," which is situated in the centre of a splendid barley country, will have their ale brewed of a pale straw-colour, and consider that all of a darker cast is adulterated; whereas the "Pottery chaps" will have it nearly "as red as blood," and imagine that paleness is only another term for smallness. At Wheelock, in Cheshire, in the margin of the salt country, are two large porter establishments watered from springs in the rising ground immediately above them; and their neighbours say that no place besides Wheelock can produce porter that is truly good, though travellers think otherwise. This porter has a black shade; but peculiar taste may not depend so much on the quantity or colour of the malt, as on the selection of the hop, and less on either than the fermenting heats; nor yet on these together so much as on custom, founded on ancient practice; and the brewer is in a great measure bound to conform to the will and taste

of his customers thus formed, whether it be refined or vitiated, addicted to sobriety and taste, or given to wallow in the depths of dissipation: as the market is, so must be the commodity, or it will cease to be a market. It is, however, in the power of a skilful brewer to improve the quality of such beer by gradual means, which he may do almost imperceptibly, until the public and himself will be equally gratified; it is moreover his duty; and amendments of this kind *never* go unappreciated.

CHAPTER V.

MASHING.

REFLECTIONS—QUANTITY AND QUALITY OF MATERIALS—OARS AND MACHINES—INITIAL HEATS—STATE AND CHARACTER OF CONSTITUENTS—ATMOSPHERIC DATA—THE MASHING ATTEMPERATOR—STANDARD HEAT—VALUE OF THERMOMETER—BENEFITS OF ATTEMPERATION—PROGRESS OF CHEMISTRY—NEW MASHING SYSTEM FOUNDED ON PRACTICE—TRANSMUTATION OF INGREDIENT SUBSTANCE—RESULTS OF EXPERIMENTS—DEFECTIVE PLANS—COMMERCIAL COMPARISONS—EXAMPLES OF BREWING—INCREASED PROFITS.

Lord Bacon admonishes, that he who would duly prepare himself for business must not be a follower of custom or antiquity any more than of novelty, neither must he be servile in his submission to authority, hasty in his affirmations, or too sceptical in his doubts; but must place each particular in the position assigned to it by proof evidence. He must have prudence enough to discover the lapsings of truth into error, and the conversion of error into truth, from a just knowledge of his own nature, and a correct sense of the scale and measure of his own ability in judgment; complying with the nature of others, and surveying the order of affairs with one eye, and their relative uses with the other; seeing also, that as discoveries proceed, the art of discovering advances with them. Man should not be vain, as the same moral philosopher reflects, in communicating the knowledge he has acquired, nor cunning in the concealment of what he knows, but ingenuous and free, rendering his subject suitable to the under-

standing and capacity of those whom he intends to enlighten or improve.

With these sentiments before him, an author must feel desirous not to indulge in superfluous words or double meanings, nor to pretend to any kind of mystery, but to be plain and intelligible, treating his subject fairly, truly, and practically, with rationality and unlimited candour; for science has the effect to open and ennoble the mind to experience; but quackery and conceit only mystify and mislead, thereby debasing the character and the object pursued.

Brewers have always experienced great difficulty through their inability to maintain, increase, decrease, or vary at pleasure, the heat of the whole mash: a power which it is the object of the present chapter fully to confer as an essential boon. We may really be astonished that through ages, when many valuable facts might have been apparent, and would have been elicited by careful attention to the progress of the mash, the tun did not derive improvement from the introduction and application of some machine contrived to neutralise the variations of temperature arising from change of season and other causes, and which must have occasioned incalculable loss and inconvenience in every brewery.

Each generation happens to produce its class of men who consider the age in which they live to be as perfect as necessary, and are therefore content to sleep in hypothetical security, letting events pass as they are, unless improvements actually suggest themselves to their own minds, or come recommended by personal friends. These are they whose supine doctrine tells us that nothing more can be done towards converting malt into wort, than is done already:—so men said years ago, when 75lbs. *per* quarter were considered the attain-

able *maximum*, though 90 lbs. and more are now realised, so that such people judge beyond their own comprehension, and so will continue to do till convinced to the contrary by reason, science, and practice. If we consult the most intelligent and well-informed observers, we find them frankly admitting that the art is either misunderstood, or so insufficiently known, that a vast deal has been remaining to be discovered. They know that the merit and value of a thing are ascertained by comparing it with others, and the result of that comparison they term experience; but here the ground of true comparison has been wanting, and consequently the *summum bonum* has not been attained except in the imagination, and there only at an outstretch. Now, although the practical brewer has not opened the eyes of the otherwise discerning to a just conception of this subject, because he has not clearly understood the true principles of dissolution and transmutation in the components of malt, yet certainly many have unconsciously approached the criterion consequent upon the discovery of that certain "something" now at length found out, clearly understood, and reduced to practice.

Few,—very few until lately, were the brewers at all acquainted with the secret workings of hot water in the mash-tun; and the best of scrutineers could do no more than imagine this incomprehensible "something," in forming or developing the sweet principle of the grain, on which the successful issue of the mash, the after process, and all the qualifications of the various properties connected with them, must ever depend. The number of practical brewers acquainted with the science of chemistry to any available extent, especially in provincial circles, is still very select; and fewer yet possess knowledge sufficient to enable them to make elaborate analyses of materials; so that we did not become

acquainted with the nature of this secret till the chemists of the nineteenth century spread a diffusion of light abroad upon the world, and encircled a special halo round the brewery by discovering, not largely, as to fill a nutshell, but within the bulk of a mite, the existence and superlatively powerful properties of DIASTASE, and the necessity of watching and humouring it. This generation has been taught to see this, or at least to acknowledge it, till men of sense cannot longer urge that the further progress of improvement is impossible or impracticable: as well may they say that mucilage is of equal value with saccharum in the composition of malt-liquors, as to deny that improvement must take a new and wide range; as well may they contend that the niceties observed by ingenuity and perseverance are equivalent to a mere waste of time, talent, and patience, and that every notion of improvement is a chimera, because, forsooth, persons like to stumble in darkness, as to deny that modern chemistry has thrown open that door to the hitherto hidden area of perfection round which authors and operators have long been hovering, like bees and butterflies, round some captivating flower, enveloped in a web of gossamer. Self-sufficient declarations must cease, whether parties have been dilatory on the one hand, or extravagant and presumptuous on the other.

Experience teaches all practical men to avoid extremes of temperature on either side, and for various reasons which shall now be made to appear in a few truthful and intelligible words, devoid of all mystery and doubt. The brewer having selected his barley from the best market and his water from the choicest fountain, his next object is, to know how to use them to the greatest advantage, which undertaking is often attended with difficulty, and especially when the selec-

tion has not been made according to his wish, or when the malt has not been properly malled, so as to loosen the farina without cutting the corn into segments.

In the first place, it is always advisable to have the materials ready over night, as the contrary practice has a dilatory appearance, and is often the cause of unforeseen delay; for if one thing is unready when all are wanted, the whole must stand waiting, to the great hindrance of business. This advice is supported by common prudence, and by two useful ancient maxims, one of which is, "*Leave nothing undone till to-morrow, which to-day can accomplish;*" and the other is the wholesome proverb that "*The early bird catches the worm.*" In fact, the hope that encourages him not to rest, and that eye of his which oversees his engagement, must dictate this course to him as the most expedient; and having accustomed himself to "*plough deep while sluggards sleep,*" the retrospect yields a consolation in the idea that cherishes the knowledge of having done right; which idea hope cannot suggest, in consequence of the existence of a chance of doing wrong.

We can fairly presume that in the middle of the nineteenth century, when art is fertile and fine, and elegance accompanies every acquisition, no need can obtain for writing an essay on the necessity of cleanliness in the brewhouse and utensils, since no man can tolerate the slightest deviation from it.

In the next place, take the hint already given, and mash early in the morning; and if the mashing liquor shall by accident attain the boiling heat of 212°, it must be slackened down to the temperature wanted, and precautions must be taken to prevent its becoming hotter in future than is necessary for mashing, particularly where the advantages of good calcareous water exist. On the contrary, if local circumstances enforce

the use of such soft waters as contain ammonia and animal matter to an injurious extent, some boiling with proper *correctives*, would be beneficial as a curative of the disorders engendered by their impurity. It may be objected that the sulphuric acid and lime which constitute the sulphates and harden water by their presence, would be expelled and precipitated, if saved in the hot liquor back during the boiling of the worts; but this, *with moderate boiling*, we have no need to fear, because saccharum, the basis of our commodity, is a powerful solvent of lime, and the strong chemical affinity of the compounded wort for both these desirable constituents of a hard brewing water, renders their detention and amalgamation peculiarly and particularly beneficial.

The act of infusion, or mixing the liquor with the malt, is done by bringing them together in such manner within the mash-tun, and so taking care to preserve an equal penetration by the fluid throughout every portion of the solid, that the process of solution be no where prevented or retarded by inequalities. To effect this purpose properly, some brewers introduce 2 barrels of liquor to each quarter of malt employed; others turn on $2\frac{1}{4}$ or $2\frac{1}{2}$ barrels, either at once or periodically, according to custom, old or new system pursued, or other attendant motive; $1\frac{3}{4}$ barrel will, however, sufficiently saturate the malt, especially if let into the tun at a proper heat, and at the same time and speed as the malt is running in from the hopper above, or otherwise; but if at the same time the operation is performed by the common mashing oars, the mash cannot be properly made, because the balling of the malt, and the cooling and in part acetifying of the worts and goods cannot be prevented. Nothing but a mashing machine can do the work quickly and efficiently where the body of goods is of much magnitude. If the object

sought were no more than a solution of the sugar provided by the former partial vegetation of the seed when malting, why should the operatist, in thus mashing or compounding his elements, be so particular in his heats, as shall presently appear? Why should such diversity of opinions prevail, since we know that water of almost any temperature will readily perform this simple office? Why do many who know not the use or value of the thermometer take the precaution to see their faces in the liquor intended for the first mash, as in a mirror, before they add the first malt to it, if they have no object or solicitude beyond obtaining a mere fermentable sweet? This peep-show plan seems to have been a general test of the ebullient principle, anterior to the introduction of the instruments, though the silliest *brewer* of the present day would assuredly not think of mashing with boiling liquor, for he cannot wish to *scald* it.

Malt, however well made, as seen on reference to our analytical table, Chap. II. p. 28, contains 30 *per cent.* of sugar and mucilage in about equal portions, and from 50 to 60 *per cent.* of starch, with 12 *per cent.* of hordein or unconverted farinaceous matter, the remainder being composed of albumen, gluten, and a little resin. Under this composition, if the mashing liquor have been too hot, the consequence, even if balling have been prevented, which is improbable, will be a gelatinising or setting of the whole mash; and though the sugar and gum (or mucilage) may have been dissolved, they will be so enveloped in the pasty mass, that not a gallon of wort, as in the case related at p. 22, can be disengaged and drawn off; and if the mash is made at too low a heat, only the 30 *per cent.* of the corn reduced to sugar and mucilage by malting can be made available, which will show an extract of about 35½ lbs. to the quarter by

Long's saccharometer; and although one-half of this wort is decidedly the best that can be obtained under any circumstances, yet the whole compound will be of the character called *mawkish*, or inclining to insipidity, because the most valuable properties are neutralised by the equal amount of mucilage, which is destitute of sweetness. This wort will also be foul and white, like thickened milk, owing to the presence of a large quantity of starch and some hordein, *both in their primitive state;* for although they disengage themselves from the goods, and run off with the mucilage and saccharum, they do not dissolve or yet affine with them, but are merely held in mechanical suspension; and the starch would ultimately precipitate itself to the bottom, and granulate like laundry starch, unless immediately subjected to fermentation, in which case it would create more evils than benefits. Thus we see that by treating the malt erroneously we produce nothing on the one hand, and only about two-fifths of the capable produce on the other; so that it is hence evident that some intermediate stage or course is required; and the nearer we approach perfection, the more we increase the quantity and quality of the beverage extracted.

Experience teaches this aforesaid fact to all brewers; but they are not all equally well versed in the causes that operate to bring such different results; nor are all aware that in either of these examples the whole starchy portion of the malt is entirely lost to the trader, not having been developed in a tangible way. To realise such an amount of extract as would be satisfactory, we must use a certain quantity of water, and no more, at such a temperature as will dissolve the starch and convert it, with as much of the hordein as possible, and assimilate these two constituents with the saccharum, by the chemical transmutation described in Chap. III.

p. 91. The gradation of the converting process will thus arrange itself:—The 15 *per cent.* of sugar will not undergo any perceptible change of character, but will, to some little extent, officiate as a saccharisor by contagion and assimilation, aided, of course, by other constituents and circumstances; the 15 *per cent.* of mucilage will become sweet, and partake of the nature of sugar; the 56 parts of starch will be macerated by the gluten and a principle that accompanies it, and will then become mucilage, and some of it will be again transmuted into sugar; and the more matured portion of the 12 *per cent.* of hordein will assume the mucilaginous character; but the perfection of these transformations will be in proportion to the temperature of the mixture, the skill of the operator, and the means which he has to carry out his designs.

To proceed with the same subject in a more lucid, and, it is presumed, a more scientific manner, we may observe, that in consequence of the great discovery made by those very eminent French chemists, MM. Payen and Persoz, we prove that by right application of certain principles contained in hot water, grain, &c., the gum that the maltster leaves in his malt, and a great proportion of the starch also, can be made into a sweet liquid, and that, too, chiefly at the expense of the very ingredient, as will forthwith be shown, that causes turbidity, acidity, and the long train of misfortunes to which brewers have heretofore been liable, and with which, consequently, they are too well acquainted: hence it is that for the first time an instrument can be placed in the hands of the managing operator, by which he can now clearly see the nature of the mashing process, examine its capabilities fully, and select such heats, and maintain them such time, as his advanced knowledge dictates and his business requires. This is

a mashing machine of entirely new construction, which also embraces the character of an attemperator, by which the casualties already named, and many more, will be effectually avoided. The great necessity of such an introduction has become imperatively urgent, and the advantages derivable from it can easily be demonstrated, for they consist in its *entire efficiency* and its *profitable utility*.

The multifarious opinions by the host of brewing writers and writing brewers on the subject of mashing heats, since the reign of George II., when his physician, Dr. Shaw, first let light into the brewery, would afford a rich fund of amusement to the curious in thermometry and to the fastidious connoisseur in ales, were it consistent with the measure of the present design to collect and contrast them; but one modern writer, in particular, attaches much importance to atmospheric changes, and assuredly he cannot attach too much. The valuable observations on this head by the "Scottish Ale-brewer," to the extent that they reach, are declaratory of the present author's own practical views, and give pleasurable expression to a train of his preconceived ideas. Mr. Roberts believes that the great aim of all brewers (but he believes more than enough) is to ensure an attendant heat of 147° to 152° to the wort running through the mash-tun tap; and that if they are successful in obtaining this, with a free and transparent stream of wort, carrying a fine pearly head, they are satisfied with their own judgment, and rest contentedly upon their oars with self-gratulation.

But, as he rightly sees the misfortune, the temperature of the atmosphere will sometimes reduce that of the unemployed grist or bruised grain 25° or 30°, and at others 40° or 50°, according as the state of the weather may be; for if tried by a thermometer soon after

preparation, it will vary from 80° to 90° in the bulk; but as it lies and mellows, it also cools and imbibes more moisture from the superincumbent air than it would have done if kept whole; and as this absorption of atmospheric damp amounts to the same effect as drinking a certain quantity of cold water, and is apportioned to its chillness, a hotter mashing liquor will be demanded accordingly, and more especially if it have lain some days in its bruised state. Moreover, these variations in the atmosphere, which may range as wide as 30° or more, will also necessarily affect the goods in the mash as well as the resulting wort, cooling both more quickly at a lower than a higher temperature; in consequence of which a still hotter liquor must be employed in colder weather, unless we can be allowed to say that we can prescribe a remedy; for that can most assuredly be done.

Whatever be the temperature of the malt or grist, of the water or the atmosphere, whether varying or stationary, prior to the admixture, the apparatus may be heated either before or after the ingredients are poured into the tun, or while infusing, to any degree that may be requisite to bring the goods from an extreme to a mean and desirable warmth; but a little experience will enable the brewer to find that the better way is to defer the attemperation until the machine, as a masher only, has blended all the malt and water into a homogeneous mass; for where it is to be used, the mash can be made with liquor from 10° to 30° lower than the prevalent and often dangerously high practice, by which new method and amendment in the art the goods will be gently operated upon, the slightest risk of setting them will be avoided, and the malt will be better prepared for the forthcoming accession of heat found neces-

sary to complete the chemical organisation of the constituents composing the mash.

The intervention of philosophical research has determined that the desired metamorphosis of the contents of the brewer's mash-tun will require the process to be continued several hours, and that the solid and fluid particles be kept in contact at the heat of at least 160°. By the time that the first mashing is finished by the old process, the heat of the goods is always many degrees lower than 160°, and is seldom, if ever, above 150°, even in the summer season, though the water may have boiled at 212°; and though such a medium might be said in common phrase to "answer" for the time being, in a common way, yet the position cannot be retained during the space necessary to produce the desired saccharisation, notwithstanding frequent applications of additional hot liquor, regardless of its disproportion in comparison with the quantity of malt, even though it be aided by the quickest possible operation of the old cooling mashing machine. It has recently been observed by certain practical gentlemen of considerable repute in the brewing world, that if more than two barrels of liquor *per* quarter are used in the first mash, the diastase, and the ingredients on which it would operate, will be too much diluted and weakened, and consequently their respective atoms will not be sufficiently in contact with each other to effect the necessary conversion.

Kirchoff, whose experiments are recorded in the fourteenth volume of Schweigger's Journal, saw something of a secret movement, but could not find the true cause any more than others. He saw that barley-meal contained both gluten and starch, that starch could not be converted into sugar by merely infusing it in water,

and that gluten did not become saccharum by the like inefficient mode of treatment; but that a mixture of pure pulverised wheat gluten and potato starch, by being infused in water at a certain temperature, caused the conversion of the starch into sugar after a certain time; and he afterwards found that the action of the gluten of malt would produce abundance of sugar from raw grain; and why? It is thence evident that some principle connected with the gluten acts upon the starch, converts it into gum, acts again upon the gum, and sweetens and changes it into sugar. It is in reality the diastase, that unvoluminous discovery of the Frenchmen above-named, which has been latent within it, waiting only for the means of action which a proper temperature alone can exert, in order to do the work of transmutation silently, secretly, and radically; for, like jalap, it works best when kept at a certain congenial warmth.

Thus it may be seen that great cause exists for the introduction of an attemperating power, capable of acting as a saccharifier in transmuting the goods to a new state, which entirely depends upon the mode of operation; and having noticed the utility of an efficient mashing machine, which shall perform its appointed work in the manner least prejudicial to the future wort, the author begs now to introduce his patented invention, as an apparatus adapted to the purposes required in this double capacity; and to explain the principles upon which it acts, both as a mashing instrument and as an attemperating medium. These requisites and many others will be found combined in

The Mashing Attemperator.

The motion of this apparatus and the manner of working it, with its effect as a mashing machine, being of

the ordinary description now employed in the best establishments, nothing has now to be particularised except the principle which constitutes the novelty of its character: of course it revolves in the usual horizontal way, though its mechanism is somewhat different. The shaft and arms, or rakes, in the first place, are made hollow for the conveyance of hot or cold fluids, and through these hollow branches hot water or steam can be introduced at such times, and in such quantities, as the operator may require; the same being conveyed down the central shaft, or around it, through a revolving steam box, which is a modern invention of the author's; and from the middle of the shaft directly to the farthest rake, where it commences its tortuous course within the body of the mash, and through the machine, on its return towards the centre, where it is discharged in an exhausted state into the atmosphere. Thus the heating medium is first conveyed to the outer portion of the goods, because there they cover a larger field of space in proportion to the distance travelled over by the machine; and by contriving this arrangement and that of the pipes throughout, an equal distribution of caloric is every where ensured.

The first advantage of this apparatus, its *entire efficiency* as a diffuser and controller of heat, as well as a masher, is explained in the description here given; for when it is heated and put in contact, through the rotatory motion, with all parts of the mash successively, density or mobility of parts offers no impediment to the equal diffusion of the attemperating heat; but on the contrary, the caloric is equally circulated throughout the tun after the first revolution or two from the admission of the steam or hot water; and the temperature of the mash can either be preserved at an uniform standard, or may vary according to skill or pleasure. Expe-

rience, nevertheless, fixes a standard of 165°, and neither to rise above 170°, nor to descend below 160°, lest the powers of nature be paralysed by excessive heat on the upper hand, or soured by sluggishness on the lower.

Here the use of the thermometer, as a standard of temperature, must be strikingly obvious; but when we consider it as an implement of science and not of art, as a theoretical test and not as a problematical means, as an indicator of heat and not the cause of it, we have attributed to it all that belongs to it; but the brewer wants more: he wants, in fact, to attemper his heat to his subject, and he wants a thermometer to prove that it is properly attempered.

Even so far back as the days of Richardson, thermometry was considered an useful science, and was urged on the brewer's attention, though the instrument is now scarcely known to many who pretend to be practical brewers. "It is evident," says the veteran, "how much the use of the thermometer ought to be studied by the brewer, in order to ensure him that certainty of success which he cannot by any dissimilar means obtain. Without this instrument it is *impossible* he can accommodate his practice so as to secure to himself every attainable advantage. The discrimination of the senses is limited and irregular. *Beyond the temperature of the body* our judgment of heat cannot reach, and *within that degree* it is very incompetent. A variation of a very few degrees, which the instrument only can determine, produces effects no less extraordinary in themselves than important to the brewery:" and after this he proceeds to say, that "many *disgraceful* properties of beers" arise from a want of the proper knowledge and use of this instrument. His contemporary, Baverstock, though opposed to others of his views, agreed with him on this point, as he says, "The eye or the touch can

afford no tolerably certain direction as to the heat of water below the boiling point, or as to the heat of worts, otherwise than according to the accidental warmth of the finger at the time it is applied. The natural heat of the human body in health is 96° by Fahrenheit's thermometer." This is the language of experienced men of the old school, the latter of whom had to encounter a prejudice so strong, that prior to 1763, when he became partner with his father at Alton, he had been obliged to conceal his instrument from paternal eyes; but we find no such expressions in Combrune, whose work came out within the preceding year.

The incompetency of the human body as a test of heat, is thus still further demonstrable from daily occurrence: one man shakes hands with two friends at the same moment; one of these feels warm to him, and the other cool; the warm man meets with a fourth, who remarks how icy his touch is, and the cool man with a fifth, who pronounces him warm at least, if not hot; and all this because the five men are differently attempered within. Again, invalids complain of excessive cold or heat, when robust and healthy people feel little variation or none; therefore the body is not adequate to the task of judgment without collateral dependence; and the only dependence now and long since known, is a correct thermometer; and with that as an auxiliary, the mashing attemperator can be pronounced, without a moment's hesitation, a tested apparatus far superior to any other power-machine or hand-implement ever yet ushered into the brewing plant, and may safely be challenged against all competition in its first attribute of *entire efficiency*.

I. As a diffuser and controller of heat in the mash;

II. As a concentrator and an economiser of the extract;

III. As a promoter of alcohol;

IV. As a creator of a delicious flavour, and of brilliancy and durability in the production; and

V. As a saccharifier and rectifier of imperfect malt.

Let us now proceed through these heads *seriatim*, and shew how this invention is

I. "*A diffuser and controller of heat in the mash.*" We admit that brewers, or some at least, have become acquainted, to an extent, with the nature of the truisms here advanced; but they have been curtailed in their system by limitation of time, which has hurried them through their work, to the great deterioration of their property. Diastase, like that leaven spoken of in scripture, which the woman hid in two measures of meal, until the whole was leavened, is thoroughly searching when once loosened within the volume of its operation; but it must in like manner have *time* for its performance, and its demand is peremptory. Its astonishing principle in converting starch into sugar, at the rate of two thousand parts of starch to one of diastase, is named in Turner's Chemistry, seventh edition, by Liebig and Gregory, which is very high authority; but they apprise us that this wonderful conversion requires *some hours* to be complete, that the diastase will not act freely unless the temperature exceed 158°, and that it does not combine with any other substance. "The paste of starch," say they, "speedily loses its gelatinous consistence if an infusion of malt be poured on it. It then forms a mobile liquid, and if there be enough of malt, the starch is completely changed into grape sugar *at the end of some hours*, provided the mixture be kept at the temperature of 160° or 170°." (See back, p. 59.)

All brewers are aware, that in proportion to the height of colour in the malt, will be the diminution in the quantity of extract which it can yield: amber, for in-

stance, does not afford so much as pale, and brown considerably less than either; which difference arises from the degree of destructive heat suffered by the diastase or saccharising principle of the grain, while it lay upon the kiln, and which principle acts the part of a ferment in the mash-tun, proportionate only to its strength. They who have seen the evil of starving the mash, have been led by theory to err in the contrary extreme, by mashing too high. The eccentric Dr. Ure, in his Dictionary of Arts, Manufactures, &c., page 98, puts this great and infallible truth into an unequivocal light, by publishing an experiment, in which he stirs from 6 to 10 parts of finely ground pale barley malt, into 400 parts of water heated to 80°, raises the heat of the compound to 140°, and then adds 100 parts of starch, which he also stirs well into the first mixture; again increases it to 158°, and keeps it constantly at that point, or between it and 167°, as extreme limits. The solution, which originally is milky and pasty, becomes thinner in 20 or 30 minutes; and soon afterwards, as the starch bursts into gum, is nearly as fluid and limpid as clear water. This fluid is now available for two very different purposes; for if it be quickly raised to the boiling point, *to prevent the further action of the malt* upon the starch, and then be suitably evaporated, "it may serve for those purposes in the arts to which gum is applied;" but if, on the contrary, this same fine fluid, which in this state he declares to be a mixture of mucilaginous gum with a *little* starch and sugar, and to be called *dextrine* by the French chemists, be chosen "to promote the saccharine fermentation for the formation of beer," he insists that "*we* MUST *maintain the temperature* at between 158° and 167°, *for three or four hours, when the greatest part of the gum will have passed into sugar.*" Hence the desirableness of obtaining and preserving this sta-

tutory heat in the mash, which can only be done by attemperation.

So important has the preservation of the proper heat been considered, that several have written on this subject, of which the fallacies enumerated in the introductory chapter, page 21, are instances, and many other contrivances have been brought into use in distilleries as well as breweries, in order to break up the goods speedily, and with as little loss of heat as possible; but, for the reasons there stated in substance, nothing has been done that was calculated to sustain it steadily, and accordingly the results have been imperfect; no need therefore remains to submit further evidence of the superiority of the theory here propounded, of its truth as a practical measure, or of the necessity of its application in either brewery, distillery, or vinegar works, as the brewers who have adopted it are the best judges of its superior efficiency; therefore the inventor at once proceeds in his endeavour to make the system of his first mash understood, as an advantage of importance to all traders who adopt it. He never mashes with liquor hotter than 160°, and he blends the malt with it as it runs into the tun, by the use of the mashing-machine alone; and his plan is, to run on from $1\frac{3}{4}$ to $1\frac{7}{8}$ barrel of liquor *per* quarter, and to mash long enough, without regarding diminution of heat, to separate every corn from the rest, and to surround it with the infusing liquor. The mash is then covered down, and allowed to stand from half an hour to an hour, or during such time as, from inspection, the whole interior of the husk will take to be saturated with liquor. After being satisfied that the malt is prepared for a finishing operation, the mashing-machine is again put in motion, to act upon the goods in its new character of an attemperator, by imparting the caloric, now passed into its hollow

rakes, to the mash. By this proceeding, the whole of the contents of the mash-tun are raised from 130° or 140° to 160° or 170°, in 20 or not exceeding 30 minutes, and are maintained at this heat for three, four, or six hours, according to the colour and quality of the malt, and the discretion of the brewer. Thus a principle is carried out on sure grounds, which neither double mash-tuns, nor fixed steam, nor hot liquor-pipes, nor an additional machine, nor the repeated and erroneous application of extra boiling liquor among the goods, or such as is very hot, can at all comparatively effect: all these have totally failed, from the impossibility of conforming, through such means, to the nature of each different constituent, and to the necessities and chemical affinities of all.

Such is the retentive character of dense fluids, that when the quantity used does not exceed 1¾ barrel to the quarter, and the heat of the mash is properly elevated, the contents of the tun do not materially part with their caloric during as much as six hours; and the worts are as sound at the end of this time, or even after standing twice as long, as they are at any intermediate or former period. How different is this very important condition from that of worts which are extracted from more fluid mashes, and indeed from the state of those denser worts that are occasionally, but experimentally, drawn by other plans! particularly such as are subjected to a prolonged agitation and oxidation, during the most critical and least safe period the mash can experience! Of this character especially, it may here be in place to notice the half-made worts that are removed from the goods, heated, and again and repeatedly pumped up upon the mash, on the plan of John Long, of Dublin, adopted in 1790, his specification for which appeared in the Repertory of Arts, &c., Vol. VI. p. 297. This practice,

which was found not to answer better than the rest that have been alluded to, has recently been revived under the new title of "Calorific Infusor," tried, and again abandoned, as were all the others before it.

Reverting, then, to our duty as brewers: before an attempt is made to saccharise the malt in the mash-tun, every particle that constitutes the farina should be saturated with liquor of a moderately low temperature, which will dissolve the originally-made malthouse sugar *first*, and give it time to flow out of the fractured husk, and to make way for the advancing liquor into the expanded pores and vacant cells, towards the interior of each particle.

The course open to us, then, is to take our time, and judiciously to proportion the liquor according to the malt, applying the attemperator at a proper period; for by so doing we make the most economical appropriation of the gluten, diastase, starch, and gum, during the first and *only* mash; whereas without such an arrangement we shall not be able to reduce this new and valuable theory to practice; but with such a machine it can be done without the slightest possibility of danger or risk, and with certainty and precision.

It has been somewhat unguardedly objected, that when one substance changes its character and complexion to become another, it must necessarily undergo an increase or decrease of some of its elementary gases, or that, in fact, a chemical change must transpire, and gases must evolve, as in the fermenting gyle, or as occurred in the first malting process upon the floor, where certain elements were imbibed, and others were emitted, which interchange was perceptible to the outward senses; and the objectors add, that as no such evidence exists in the brewer's mash-tun, no further

conversion of the grain takes place between the malt-house and the fermenting gyle.

This objection to our theory may at first sight appear formidable; but it is at best but a one-sided view, which a little further enquiry and observation would have demonstrated; for the chief beauty of science lies in being able to prove, in a variety of ways, whatever comes within its scope, but it is the province of an ignoramus to assert that which he cannot prove; and the author verily believes that this gainsaying is limited to two or three inexperienced and thoughtless young men, and that it has originated as much from their sheer ignorance as from any vicious motive; but the following may perhaps lead them to the light, if they are disposed to be enlightened. It is true that the external appearance of the mash does not present any decided evidence of chemical change; but, it is asked, would not the extreme density of the whole contents of the mash retard the ascension of gases, if any were generated during this first mash? We know that fluids of the lowest specific gravity part with their aërial or gaseous contents with greater facility than richer liquors: thus soda-water, champagne, bitter ales, and small beer, give off their *fixed* gases more easily and more copiously than stout and full-bodied and dense new ales; and though it may not be wise to aver that gases are evolved in the mash-tun, it may not be amiss to notice another circumstance which may tend to shew that such an occurrence is far from impossible. All practical brewers have had opportunity to observe, that just as the copper "is through," the furnace fire requires damping or checking, to prevent the swelling worts from flying over the edge of the copper from their tumultuous ebullition; and that at this critical period the turbulency of the wort is always

preceded by a foaming head, which gathers and breaks violently for some minutes, during which time it is not unlikely that something more than caloric is exerted in the struggle, particularly as the excessive agitation soon ceases, and is not resumed upon the introduction of more caloric.

The boiling of fermented beer evinces the same appearance; so that this phenomenon seems pretty evidently to imply, that upon the accession of surplus heat and motion, gases are emitted in both cases alike; and as the same convulsive foaming occurs in worts that have been made from water that had been previously boiled, the escape of fixed air cannot in this instance be the cause; and besides, mere water could not, under the circumstances, absorb a thousandth part of the quantity developed. These aërial vapours, then, consist of an accumulation of atmospheric air that formerly inhabited the grist or bruised malt, and that were absorbed and retained by the wort during the mash; therefore the phenomenon is accounted for, which is one step gained towards the solution of our problem, and as such, is not mere speculative theorising; and though the original objection raised against the theory of transmutations in the mash-tun, has not yet been fully met, it may at once be answered that no evidence of the evolution of gases in the mash-tun is sought, because the circumstances attending the diastatic saccharine fermentation and the vinous processes are widely different, and that our senses, our instruments, our experience, and our actual knowledge of the metamorphosis in question, combine to render objecting observations unavailing; but as even this species of argument may be deemed illogical, perhaps the following is more lucid and conclusive.

Every brewer who uses a thermometer in his mash-tun, may observe that during the first 15 or 20, or

perhaps 30 minutes of the infusion of his grist, and consequently that when his mash is at the hottest, a spontaneous and gradual increase of temperature takes place; and one moment's reflection must convince him that this accumulation of caloric, which is similar to that which subsequently arises in his fermenting squares, is caused by some chemical action within the volume of the mash; and he will further reflect, that the well-directed efforts of nature soon afterwards become retarded, then stayed, and ultimately are reversed, all through a compound relaxation of heat, from the standing of the mash, and the cessation of the chemical action.

If this is not enough to lay all speculative scruples upon the point to rest, the following assuredly will. Guerin Varry assures us, and Liebig has lately corroborated the testimony, that diastase liquefies starch and starch mucilage, converting them into sugar, without the disengagement of any gaseous products, and that "*the action takes place even in vacuo.*" Hence in this, as in other chemical metamorphoses, the elementary gases do not perceptibly evolve, which shows why they are not recognised in the brewer's mash-tun; but they arrange themselves and form new compounds according to temperature and substance, and to their consequent natural affinities. Who, then, can longer presume to deny the theory of conversion, or reject the discoveries of the chemist, and the practice founded thereupon by the co-operation of the artizan? or, in a plain word, who can doubt the efficient merit of a machine, such as the one here described? The objection must be particularly out of place, after viewing the attemperator in its next light, as

II. "*A concentrator and an economiser of the extract.*" The following will elucidate the stages of saccharific transition in practice. The author, by the aid of this

machine, took a course of experiments, the result of which was conclusive and satisfactory that the theory which he had sought to establish was founded in truth. Samples were drawn from the mash-tun at the end of each hour, after the heat had been raised to 160°, and was kept above that point; and so small was the deviation in any case, that the progress here reported corresponds with each experiment to a nicety not worth distinguishing:—

Standing of the tap in hours.	Density by Dring and Fage.	Increased density.
1	35·9	0·
2	38·	2·1
3	39·5	1·5
4	40·3	0·8
5	40·8	0·5
6	41·1	0·3

Total increase 5·2. All these mashes were of pale malt and of the same quality, and just two barrels of liquor were used *per* quarter, at the statutable temperature of 160° F. After mashing about fifteen minutes, all the malt was well blended with the liquor, and the whole had a mealy smell and milky appearance, the heat of the mash at this period being in few of the instances higher than 137°. After a limited time, steam was passed through the mashing machine, which was kept moving; and in about half an hour the mash usually attained the temperature of 165°, below which it was never allowed to descend, but was in some instances elevated to 166° or 168°, by merely having recourse to the steam cock for a few minutes when the heat was receding below the point considered to be expeditiously saccharising. At this period, as taught by chemistry to expect, the appearance and odour of

the mash underwent a very remarkable change, the former thick mealiness being dissipated, and the extract becoming quite clear and transparent, and so it always continued to the end.

The subjoined table will illustrate the effects of a right application of heat still more strikingly, where the malt is mashed with the ordinary quantity of 1¾ barrel of water to each quarter, or one-eighth less than in the former case, the extract coming off thus:

Hours infused.	Density.	Increase.
1	45·	0·
2	47·4	2·4
3	49·	1·6
4	49·9	0·9
5	50·5	0·6
6	51·	0·5

Total increase 6. In fact, all who have introduced the system now admit that the worts are drawn at least 25 *per cent.* heavier in saccharum than they ever could be before the Mashing Attemperator was erected, and that no other extant means can compete with it. One of the principal advantages of being enabled to obtain such weighty worts is, that comparatively very little liquor is required to exhaust the goods after the mash is made. For example:—if we use 20 quarters of malt that will produce 90 lbs. *per* quarter, or 1800 lbs. in all, and if we at first draw 20 barrels of wort at 50 lbs. each, or 1000 lbs. in the aggregate, we have drawn considerably more than one-half of the extract. This may be done; and when due precaution is taken in supplying the remainder of the liquor, we shall experience no difficulty in bringing off the remainder of the extract with 24 barrels of liquor, yielding on the average 33 lbs. *per* barrel, or 792 more. Thus the whole

product is obtained in 44 barrels of wort, weighing nearly 41 lbs. *per* barrel; and with more facility, because in this latter case a larger quantity of sparging liquor may be used to produce the necessary length for the more ordinary beers; whereas worts made upon the old system require boiling down to the density wanted; but the evaporation which attends that process has long stood condemned as wasteful of time, fuel, and material.

Baverstock, in his strictures on Richardson, fully explains this practice, in a manner to deter all sensible men from pursuing it. The system of the latter was to reduce the quantity of the second or last of two or more worts by evaporation, "so much as to leave the quantity as well as quality *just such as will serve the intention,*" in order to form an average standard gravity:—a work of great tediousness and no little uncertainty, besides the expensiveness of the process; and yet the plan, ridiculous as it may seem, is continued by many at the present hour.

First example, with TWO *worts.* He takes a fixed average of 29·8 lbs. *per* barrel, towards producing which he has a strong wort, weighing 34·25 lbs. when cool, and a smaller, as low as 17·6, which, to produce the required standard, must be evaporated till it is dried up to 25·35, the other extreme requisite to average the mean at equal quantities of the two. This small wort at 17·6 lbs. raw, he supposes to rise to 20 lbs. by imbibing the juice of the hops and some of the first wort retained within them; and he calculates that from 29·4 barrels, he must evaporate 7·4, the required quantity being 22 of each sort; 2 of these barrels out of 29, he allows to pass off in the passage to the cooler, "including all continuance therein," so that 5·4 barrels have to be spent by boiling in the copper.

Second example, with THREE *worts.* To average 25·55, he supposes the two best to realise 59·6 between them, which leaves 17·06 for the density of the third; which he finds to produce no more than 9·25 before it is boiled in the hop-copper, or 11·5 when it comes out, and to consist of 30·26 barrels, making an aggregate of 347·99 lbs. of fermentable matter; this he boils three or four hours, and then takes an observation, when he finds the gravity 14·5, and dividing his 347·99 lbs. by this, he has now 24 barrels remaining. "And the brewer is to form his final quantity as well as quality, by means of a frequency of such examinations of his last wort while in the copper. To occasion a sufficient increase in the density of this wort, so as to form the average required, no less than one-third of that whole quantity is to be evaporated. Let the practical brewer consider well this circumstance, and passing over the doubt and uncertainty of *ever* hereby obtaining the precise specific gravity required, let him observe somewhat on the great waste of time, fuel, and so much of the pleasing quality of the hops as may yet remain in them, caused by this method."

Baverstock's remedy is worse than the disease he seeks to cure, for he conceives the density of his wort to be affected by the depth of the vessel in which he tests it: a certain sign that he conceived it to be thicker at the bottom than near the surface, and consequently that it contained much unconverted sediment; and it would be well if the practice and samples of the last century were not troublesomely enough continued by certain novices yet in existence; but surely all skilful men must rejoice at the abandonment of all such speculation; and party gyles of all sorts, always an evil, may now be wholly abolished. The consequences of such concentration alone as the Mashing Attemperator

achieves, *considered apart from additional extract*, are therefore not only extraordinary, but are beneficial in a pecuniary sense, as seen on view of the eight subjoined comparative examples of brewings with malt that is brought to yield 90 lbs. density *per* quarter.

1. Examples of four brewings by the ordinary practice, from which the usual lengths, with table beer or return wort are drawn, either of them estimated at 1*s.* 2*d.* *per* lb.

Specimen.	Qrs. of malt.	No. of barrels.	Density.	Price *per* barrel.	Value.	lbs. extract of T. B. or R. W.	Value.	Total extract.	Total value.
				s.	£. *s.*		£. *s.*	lbs.	£. *s.*
1	10	30	26	36	54 10	120	7 0	900	61 10
2	10	22½	32	48	54 0	180	10 10	900	64 10
3	10	20	36	58	58 0	180	10 10	900	68 10
4	10	15	40	72	54 0	300	17 10	900	71 10

2. Examples of four brewings by the Attemperator, with the same made malt as above, the extract forming an entire gyle of the same densities in the several cases as before, and charged at the same prices, with the additional profit upon each.

Specimen.	Qrs. of malt.	No. of barrels.	Density.	Price *per* barrel.	Value.	T. B. or R. W.	Total extract.	Total value.	Amount saved.
				s.	£. *s.*		lbs.	£. *s.*	£. *s*
1	10	34$\frac{8}{13}$	26	36	62 6	None.	900	62 6	0 16
2	10	28$\frac{1}{8}$	32	48	67 10		900	67 10	3 0
3	10	25	36	58	72 10		900	72 10	4 0
4	10	22½	40	72	81 0		900	81 0	9 10

Total gain by the four brewings, £17 6*s.* In further elucidation of this, let us suppose that a brewer consumes 2000 quarters of malt annually at 54*s.*, and that his chief productions are Nos. 1, 2, and 3, in equal quantities, as it is presumed that little of No. 4 is

brewed in a common way of practice, and that probably the quantity of No. 1 exceeds that of No. 3; we omit No. 4 in the calculation as a consequence, which gives the average additional profit 5*s.* 2¾*d.* *per* quarter, or £520; and if to this we add the value of the additional extract obtained through the powers of the machine, at 5 *per cent.* only, and in many cases it is double of this, it gives the 20th of 2000 × 54*s.*, or £270 more, and shews the additional profit on the 2000 quarters to be altogether £790 a year; and when we deal in the extract No. 4, this profit will be more than doubled.

To brewers of strong beers, and those whose demand for inferior qualities is limited, the vast economy effected by the application of this principle of concentrating the whole produce of the malt into one gyle, however weighty, must at once be obviously clear; but where it is understood that this may be done without discolouring the worts by extra boiling, and is attended, amongst other advantages, with an additional quantity of superior extract, amounting to many pounds *per* quarter, the merits of such a means cannot be doubted by any one; but surely the trade in general must appreciate it, and particularly brewers of Vatted Beers, if only by reason of its concentrating powers. At a moderate calculation, the increase of gain is more than sufficient to pay the whole expense of the home establishment at least, which is no false theory, but a fact which the author is prepared irrefragably to prove.

Admitting as a simple hypothesis, that the saccharometer indicates the extracts by two different processes to be equal in quantity and gravity, still this will not stamp their identity in respect to *quality*, inasmuch as one may be much more mucilaginous than the other, without its gravity being sensibly affected thereby. The

very serious importance of the distinguishing properties and products of these two principles cannot surely fail to attract the lively attention of all who trade in the fluid extract of grain; for while the two widely different characters of mucilage and saccharum are blended in nearly the same proportion within the malted corn, and the inferior constituent increases as well as the superior when placed in an ordinary mash-tun, and they stand at the same cost to the trader, he certainly must perceive his interest, if he is wise, in providing the readiest, the simplest, and at the same time the most efficient means within his reach, to increase the latter at the expense of the former, thereby improving the flavour, the strength, the constitution, and the permanency of his manufacture, be he brewer or distiller.

The author dislikes paradoxical conclusions that tend to perplex others; therefore he trusts that his statement is clear and comprehensive; for though the concentration of his worts by the peculiar manipulation conducted from one hour to six, may shew an intricacy of specific gravity as great as ever between these two chief ingredients, the brilliant liquidity of the running stream from his tap shews the presence of the better and the absence of the worse. It appears that the diastase, which has been the agent in this conversion, works the most effectually when it has the greatest quantity of material to operate upon, which is a natural consequence, and is quite apparent from the saccharisation of the remaining goods, as exemplified in the experiments, the increase of density being in a ratio almost inversely proportional to the length of time they have stood over the tap; thereby prescribing a convenient and evanescent limit to the duration of time necessary to complete the approximation, as the quantity converted within

the sixth hour betokens only small increase, and is, of course, partially attributable to the evaporation of the mash; indeed, the same remark applies throughout the process to a rational extent, and some deduction should be made for this.

III. "*A promoter of alcohol.*" If this new and thoroughly chemical theory, which is here carried into practice, were ill-founded, or of doubtful benefit in its result, it would not be countenanced by philosophers at large; and much less would they embrace it as a principle, or embark in its promulgation as a doctrine; but if its basis be good, and its apex clear and accessible, then the practice of acclination must be made to correspond with the detail. One step in the way of accomplishment is to exemplify the amount of spirit produced from various materials, in order to shew how far the approximation to the character of sugar increases the tendency to create alcohol. This is proved by the simple fact that malt, which is more saccharised than barley meal, will make more spirit in proportion to its weight; and that Indian sugar and molasses will yield more than malt. The order of gradation that attends the vinous decomposition of farinaceous starch, as it passes through its stages into gum, sugar, and alcohol, shews that the original sugar is the first to decompose, that the latter formed saccharum follows in succession, that the more perfectly starchy particles are the last to yield, and that, therefore, the more the produce is purified, or converted from mucilaginous gum by transition into sugar, the more spirit it will contain; and here the principal question is, how much more spirit will clear and pure saccharum produce, than an equal quantity of matter which is half saccharine and half mucilaginous? That gum of itself will not undergo the vinous fermentation, no doubt

exists, the proof negative being before us; but "its aqueous solution acquires an acid taste in a few days, and becomes muddy." This is an old and long recognised principle. "As to strength in beers," saith an old and intelligent author, "as in wines, cider, and every fermented liquor, the foundation of it all is sugar." And again, "Every particle of it is the creation of vinous fermentation; and no such fermentation can be excited except in a liquor that is drawn from some species of sweet, and is ever in proportion to the sweet extracted."

According to certain experiments prosecuted by the House of Commons, under the joint superintendence of Drs. Thomson and Ure, a quarter of malt, with proper management, will yield 18 gallons of proof spirit, and a quarter of barley from 18 to 20 gallons, (which shews that mucilage can be brought to spirituosity when in affinity with other matter,) the best grain producing the higher quantity, and weighing 55 lbs. *per* bushel, or 440 lbs. on the whole; and the average weight of the malt being 42 lbs. *per* bushel, or 336 lbs. *per* quarter. The annexed quantities of various sugars and sweets are also each equivalent to a quarter of malt, or will respectively produce 18 gallons of proof spirits, the truth of which has been determined by an eminent distiller with whom the author corresponds: West India molasses 275 lbs., refined or sugar-house molasses 295 lbs., Jamaica inferior raw sugar 234 lbs., best West India sugar 175 lbs. This subject largely engaged the attention of Baverstock, who gave the average of sugar 200 lbs. and that of treacle 240 lbs., which last is lower than modern experiment goes, probably because as the manufacture of sugar was then less perfect than now, the molasses contained more saccharine matter. But he also notices another sweet, and that is honey, 226 lbs. of which he gives as an equivalent to a quarter of malt.

The following table of equals in productive matter will therefore be found practically useful:

Materials employed.	lbs. giving 18 gallons.	Gallons in 100 lbs.	lbs. *per* gallon.	Value. £. s. d.
Best West India sugar	175	10·286	9·72	4 11 11
Jamaica raw sugar	234	7·692	13·00	5 16 2¼
West India molasses	275	6·545	15·28	3 18 5½
Sugar-house treacle	295	6·102	16·39	3 18 7
Unadulterated honey	226	7·964	12·55	8 10 2
Best samples of barley	396	4·545	22·00	2 13 8
Malt of medium quality	336	5·357	18·66	2 19 0

Whence it appears, that if we go so far as to consider that the whole of the best sugar became spirituous in these examples, little more than half of the malt, and less than half of the barley, was turned into alcoholic beverage, though capable of a greater yield, because much of the farina or hordein remained unconverted; and it is evident from these results, that sugar formed the basis of alcohol, which is a powerful argument in favour of a saccharine extract, in preference to such as is mucilaginous, both for the brewery and for the distillery.

A few observations on the above Table, in comparison of prices and upon other commercial points, may not be altogether uninstructive. Before the passing of the Imperial Act in 1824, or at least prior to the termination of the European war, particularly in 1813, a bushel of ripe and well-cleaned barley, old Winchester measure of 2150¼ inches, and estimated to weigh from 50 to 52 lbs., was calculated to produce from 40 to 42 lbs. of good malt, worth 96*s.* *per* quarter; but the imperial measure of 2218·192 inches is above 1½ lb. heavier according to the same foundation, which is not the best; for we have seen above that some barleys weigh 55 lbs.,

and consequently that their malt will reach 44½ lbs. and would be worth 101*s.* 8*d.* at the same rate. At that time treacle was selling at 48*s.*, sugar at 90*s.*, and honey at 80*s.* *per* cwt. of 112 lbs.; and at these prices did Baverstock, often referred to by brewers as a calculating authority of his day, estimate his 96*s.* worth of malt to yield as much fermentable matter, presumed to be saccharine, as 103*s.* worth of treacle, 165*s.* worth of sugar, or 161*s.* worth of honey. This he did to prove that notwithstanding an act of parliament passed in 1812, to permit the use of sugar in brewing ale, malt was still considerably the cheapest brewing material. At the present time, when no such toleration exists, notwithstanding the great reduction which has taken place in the prices of sugars, it has still the pre-eminence; for according to the official revenue returns of the year ending December 18, 1844, the average price of sugar brought from the British American colonies was 30*s.* 5*d.*, besides a duty of 25*s.* 2½*d.*, and that of East Indian produce 33*s.* 7½*d.* with the same duty to be added, which prices have been taken in estimating the equivalents in the table, East being put for West India. The two kinds of treacle have been taken at two-thirds of the sugars, about which prices they sell, with an import duty of 9*s.* 6½*d.* *per* cwt. added to each; and honey at four times the worth of treacle without duty, being supposed native; but this article, if brought from British possessions abroad, bears a duty of 5*s.* 3*d.*, and if from foreign connexions, from 10*s.* 6*d.* to 16*s.* *per* cwt.

According to the same official document, the average cost of malting barley for the last year was 36*s.* or from 34*s.* to 38*s.*; Dantzic, free, 34*s.* or from 33*s.* to 35*s.*, and bonded 27*s.* or from 24*s.* to 30*s.* *per* quarter, duty 21*s.* 8*d.* added when malted, and about 4*s.* 6*d.* more if imported. Taking the best that can be obtained, at 440 lbs. for 38*s.*,

the value of 395 lbs. with the malt duty added is 53*s*. 8*d*. It might appear hence that barley was cheaper than malt; but if it yielded as much real saccharum, the malting process would be useless. The average value of pale malt *per* quarter for the last year was from 58*s*. to 63*s*., that of brown 54*s*. to 56*s*., and the best samples from Ware 64*s*. to 65*s*.; pale malt is, therefore, more valuable than dark, and ale than porter; for "where mucilage prevails, there will be an increase of spissitude without an increase of value." Now to treat of the Mashing Attemperator as,

IV. "*Creator of a delicious flavour, and of brilliancy and durability in the production.*" Although a gradual and very considerable increase in the absolute gravity of the first wort is clearly indicated after attemperation, yet we cannot thereby readily demonstrate the whole of the benefits arising from a judicious appropriation of the first mashing heats, and for this reason: having kept in recollection that the saccharum in some barleys is to the gum as 100 to 88, differing in others as far as 100 to 80, or as 5 to 4, and that the difference in the ratio of these compounds diminishes during the malting operation, till at its termination they appear in the malt at an equality of 15 *per cent.* each; still from the most satisfactory experiments that the author has yet been able to make, he finds no real determinable difference between the specific gravity of the unalloyed saccharum and that of the gum, nor does analogy alter the matter much; but this subject will be found more fully treated upon in Chapter VII.

The ingredient mucilage has other peculiarities which war against the interest of them that are obliged to deal in it. When blended with sugar and fermented, as in ale, for example, the sugar is always the first to decompose, and the mucilage does not transmute so fast as its

accompanying sugar, particularly towards the latter stage of the fermentation ; but in low temperatures it often happens that every trace of sugar is lost, and that the fulness of the article depends upon the perishable support of the remaining mucilage and the presence of carbonic acid gas. Be it recollected that ale, when attenuated and fine, shall retain one-half of its original extract ; yet it is by far less than half so sweet as before fermentation ; thus demonstrating that the unattenuated matter consists of an almost tasteless mucilage, attended by a bitter from the hop, which of itself would neutralise the sweet to an extent proportionate to the progress of fermentation. The want of flavour in mucilage, and its proneness to acidity, place it incomparably beneath sound saccharum, inasmuch as a smaller quantity of the latter by 90 *per cent.*, will impart adequate sweetness, devoid of clamminess and turbidity : how useful, then, must be that process which can aid the transmutation of the gum into saccharum, leaving only the more slimy portion of mucilage, or amylin, unconverted, and even softening that in its harsh temper!

A ready and common test for proof of perfection according to quality is the palate: by this simple means alone, it has been a matter of great surprise to the individuals who have but merely tasted the worts produced by the patent machine, that the increased rich sweetness and high odour should be so obvious to the senses during the saccharising process ; and the extreme brightness of the worts is also a remarkable feature. The fact that the mucilage, when in a separate state, is clammy, poor, and insipid, shews clearly that the increased sweetness of the mash must be attributed to the transformation of the gum, more than an improvement of the original saccharum of the corn.

These observations do not apply to the first wort

alone, but to the whole extract when embodied in one gyle; and the superior richness and smoothness of the perfected beer, as tested by the palate, declare its paramount virtue to be out of comparison. The action of the diastase on the more advanced portions of the starch, and indeed upon nearly the whole of it, *begins* in a way almost immediate, and certainly decisive, as soon as the heat has sufficiently advanced; for in none of the worts made by the new system, though minutely examined by a noted practical chemist who assisted the patentee in some of his experiments, could a particle of starch be traced as such by the indefinite test of iodine, though in a few instances there were slight indications that could not be distinguished from the appearance caused by the presence of amylin alone; and thus it is that future brilliancy is given and guaranteed, because all obstacles are removed by the attemperation. *The mere transmutation of starch into gum is not*, however, *the sole object, but a provision upon which greater things depend;* for it is practicable, as shewn by analysis and enquiry, as well as by the common every-day use of the attemperators in present use, that by following up the same means to a greater length of time, the advancement of the several constituents of the grain to a most valuable saccharum resembling the sugar of grapes would be more complete.

Testing wort at the tap with the tincture of iodine, has of late been considered a good practical experiment, since if any of the starch has escaped the action of the diastase, the iodine will turn it blue; but this is fallacious for the brewer's practice, because it is also a test for dextrine, and nearly all the amylaceous substances, and produces similar signs and colours. Suppose the whole of the starch to be rent asunder and the iodine test to be applied to the wort, it will give a blue or red-

dish colour; but the starch does not do this from its having partaken of other properties, but the cause of the colour is then the presence of an amylin, or the untransformed enclosure of the starch, which continues to resist the diastase, though the amidin or enveloped interior of the starch globules, have passed into sugar. Still after all, the tincture does not tinge, as is generally the case to a great nicety with the attemperated worts; it certainly shews the clearness and brilliancy to have been commanded to the full extinction of all the convertible matter; and brilliancy is as much the cause of profit as flavour, though both are better when they are, as here, co-existent.

West of England brewers and others, who vat their beer and keep a large stock, are frequently disappointed on broaching a vat, by finding its contents thick or cloudy, or "grey;" and with some brewers this is general during the warmer months of the year. Such beer often changes from tolerable fineness to a low fretful fermentation in one night; yet this fickleness and instability of the article is never experienced by brewers that *make their extracts upon correct principles*, because with them the azotised parts of the grain, the originators of these troubles, are so far reduced, dissolved, or simplified in the mash, as to render their further decay or dissolution so easy and certain during the vinous fermentation, that *the residue is less susceptible of further decomposition when in the store*, whether induced by heat or shocks. This has also been proved by experience; and besides this, we have the declared opinion of Liebig, not only to warrant the general system of saccharisation into one substance, but also to speak to the permanency of the substance itself, where he says, "There are many facts which prove that the most simple inorganic compounds are also the most

stable, and undergo decomposition with the greatest difficulty, while those which are of a complex composition yield easily to changes and decompositions. The cause of this evidently is, that in proportion to the number of atoms which enter into a compound, the directions in which those atoms act will be more numerous."

Finally, as regards the attemperation of mucilage into a saccharine consistence, it is found to be more adhesive than sugar, and this will account for Dr. Thomson's finding more of it in the last and weakest worts than in the first-drawn: it also deposits much more sediment and yeast during the decomposition, which in some measure shews its deficiency in yielding alcohol, when compared with saccharum, and helps to explain that high gravities are not always the best signs of a perfect wort. The reduction of the many distinct substances in the complicated admixture of hordein, starch, gum, and albumen, into the one pure, simple, and soluble article, sugar, renders the wort issuing from it less liable to run into an acetous fermentation, because the change has been attended by a general decomposition and purgation. Doebereiner shews the fatal effects of retaining these crudities, and has exposed them in the "Journal de Chimie de Schweigger," where he says that after trying experiments on starch, his researches convinced him that pale beer contained a considerable quantity of it, and avers that it makes it nourishing, but "at the same time disposes it to turn acid." This is the evil that has abundantly prevailed; but saccharum, which is more nourishing still, has not that tendency while properly treated; and hence the policy of converting the starch through purification by diastase; for where acidity enters, it breaks a hole into the brewer's purse. This truth being cleared up in a few words, we proceed to speak of the Attemperator as,

V. "*The clarifier and rectifier of imperfect malt.*"—A variety of circumstances have contributed to increase the intrinsic value of malt. Farmers have of late been more choice in their seed than formerly, and have exercised greater judgment in the selection of soils and manures, have improved their lands much better for the reception of the corn, and increased competition has made the maltster more attentive to his department of the preparation; and the invention and adoption of the saccharometer has doubtlessly been an excellent handmaid in inducing and carrying out the work of amelioration. Notwithstanding all this, the brewers of the present day pride *themselves* upon their increased extracts, and attribute them, correctly in some few instances, to an improvement of their own devising, either in the heat of their liquor, or upon their mashing or extracting process, or to some novel cause to which their forefathers were strangers. One difficult task, however, yet remains unfinished, which is, that not having had a fair and full opportunity of proving their superiority, they cannot be justified in affecting to display it. In dealing with flinty or otherwise imperfectly made malt, whether occasioned to be such by bad management, by unfavourable soil, or by *unpropitious seasons*, and particularly this last cause, the management of such malt is a duty of very serious consequence to the brewer, inasmuch as not only are the flavour and the amount of extract alarmingly diminished below the common average, but the misfortune is often, if not invariably, heightened by high prices; yet through the want of unanimity or faith in the trade, and the peculiar nature of the brewing business, any attempt to counteract such precarious casualties, by lowering the gravity or increasing the price of the beer, is ever attended with great risk to the trader, and is probably

followed by great ultimate disadvantage; for it is well known that brewers, unlike many other commercial men, must keep their prices almost stationary, let the market value of their raw materials be what it may.

It is really important to observe on this point, that the attemperator has been found a most efficacious machine where the malt has been of imperfect nature; for as diastase is kept constantly present and in vigour by the peculiar standard of heat introduced and prolonged, this singularly agitant property having originated at the commencement of germination and remained latent *ab initio*, until heat and moisture have been duly applied, and each particle of both has been brought into close contact with the hardy starch, gum, and hordein of the broken grist or bruised malt, these latter are forced into an active state of transformation through the restless disposition of the aroused diastase, and the result is similar to the former process of sweetening the corn by malting, but with this difference, that in the mash-tun no roots or spires spring out of the vitals of the seed to feed upon them! Now it must be admitted, that by the ordinary means these flinty and barley-like malts cannot derive much improvement by infusion, because the brewer is unable to maintain the heat of the mash at a safe and suitable temperature, or at any thing like it, for more than 60 or 90 minutes under the most favourable circumstances; and that during one-half even of this time, unless the goods are swamped with boiling liquor, the heat of the mash will not average 154°; but whether that malt be of a steely or of a deaf character, if some portion of it has germinated at all, though unkindly, the right application of the attemperator through a proper period of time will so soften the hordein and stubborn or fibrous starchy matter, as to enable the diastase to pursue its

natural and supremely active course. These impure malts contain from double to triple the amount of hordein to that of the best samples, and consequently they require more vigilant treatment and longer care to bring the saccharific particles into solution. Such malts should be ground finer or crushed better, mashed more carefully and with colder liquor, and the temperature should be raised by more stages, till the ultimate heat of the goods become some 5° or 6° higher than usual, and the infusion should occupy *considerably more time.* There are, besides, other indispensable conditions which will make such grain nearly as valuable as the more expensive, all of which will be explained to those who will possess the means of making them available.

It may be proper to observe, by the way, that another practical measure arises hence, which may one day be of vast mercantile consequence. According to the collective wisdom of such eminent men as Lowitz, Vogel, Braconnot, and some others, cane sugar, sugar of milk, *woody fibre*, and various other substances, furnish grape sugar by a simple manipulation in which a dilute acid is employed with heat and lime, the latter being introduced merely to neutralise the acid: such is the nature of things and the effect of popular science, as expressed by the greatest chemists of the present century. Distillers have for a long time been allowed to use a certain quantity of raw corn in proportion to the malt they consume; therefore it is really very important for them to know that such accustomed indulgence can *now* be fully appreciated, because the new patent process must, as it assuredly does, greatly enlarge the scope of solvency, thereby materially increasing the amount of solid extract, and promoting its richness, and consequently *augmenting the measure of alcohol.*

Worts produced by this procedure are less clammy

than those of the ordinary kind often are, and are not mawkishly sweet like the latter; and though many pounds denser, they drink with a cleaner taste and more pleasant relish, leaving the palate sensible of an agreeable delicacy, with a prominency of flavour and an aromatic odour, part of which excellent quality may truly be attributed to the action of the oil resident in the husk of the grain, which the long continued heat developes and probably increases beyond what science has hitherto discovered of its native quantity; but although this minute proximate principle imparts strength and prolongs preservation, it has a disadvantageous effect on the saccharometer, being lighter than water. When the author's attention was first attracted to this gratifying result of his mash, outwardly so mysterious at first view, he fancied that as he deviated in his management, his wort, and subsequently his beer, bore some peculiar trait, which always displayed itself in the ever interesting process of fermentation; and further observation and experience soon convinced him that some unseen principles were involved, till at length these became apparent, and the causes of variation during fermentation, and of the peculiarity in the article, were accounted for, not only by difference of gradation in the time, heat, and liquor employed, but also by other attendant causes producing their own effects.

The most important feature of his worts, because it is the most convincing, and embraces the greatest variety of consequences concomitantly, is that in proportion to the time occupied (within certain reasonable limits) in the mashing and attemperation of the goods, the less evident is the increase of density according to the senses; and although the accession of extract is at the same time duly indicated by the saccharometer, yet it is not a due indication of the quality of these highly

saccharised worts, as the ultimate character of the beer, and the additional alcohol it produces, unequivocally demonstrate. This conclusive observation is correct in practice, and further inquiry shews it to be chemically consistent, which must evidently arise from the purity and simplicity of the extract itself. At first thought it might seem to imply an absolute elasticity in the attempered worts, by which their volume had increased; and as we are assured by chemists of note that 100 parts of starch will afford 110 parts of sugar, then as six parts of malt will saccharise 25 parts of starch, yielding 27½ parts of sugar, exclusively of that furnished by the malt, the idea does not appear incredible; and it is evident how rare the fluid must have become after such tendency to change its character, and such long inducement to do so.

That the quantity of starch rendered into saccharum under circumstances similar to a good and properly made mash, exceeds the amount of its amidin, is evident from an experiment published, with many others, by the great chemist Guerin Varry, in the "Annales de Chimie et de Physique," LX. 32, where from 100 parts of starch *in the state of mucilage,* (that is, with the shells broken,) and 39 times their weight of water, mixed with 12½ parts of diastase dissolved in 40 parts of water, he formed 86·91 parts of sugar, which distinctly shows that amylin, the most obdurate of mucilage, does not altogether resist the potent impetus of diastase, though learned analysts have averred that it does; but perhaps they had not patience to give the trial sufficient time, for it has been shown in Chap. II. that the amidin of starch is but 38 *per cent.*

Whence, then, the 87 parts of sugar, if the amylin were unconvertible? And if convertible under common circumstances, why not even more so by the extraordi-

nary means expressly provided for that purpose? It may be considered egotistical and superfluous to produce any further reasons for preferring these means to enable the brewer to exercise as much control over his mash-tun as his attemperators afford him over his fermentations; for this long wished-for *desideratum* has been well received, and continues to experience daily increase of patronage from the most intelligent portion of the trade; we will therefore conclude this subject by observing that, while we are converting primary and other compounds, we transmute a gross compound into a finer and less complicated article, acquire ADDITIONAL EXTRACTS AND PROFITS *to a very considerable extent*, and are proportionately rid, to a like extent, of the impediments which until now have served only to weigh, muddle, acetify, and perplex.

CHAPTER VI.

SPARGING.

SCOTCH METHOD—ASSAY OF GOODS—PARTY GYLES—RETURN WORTS—THE HYSTRICON—GREAT ECONOMY IN TIME, LABOUR, AND FUEL—DILUTION—FILTERING MASH—PREVENTION OF ACIDITY—DIVERSITIES ADJUSTED—GRAINS—IMPOSTURE EXPOSED.

Some brewers have a practice, immediately on setting tap, of starting the sparger also, to allow the hot liquor to flow upon the goods quietly and rather slowly, but at the same pace that the wort is running off; which course they continue without intermission, passing and keeping as much liquor on the goods as they require for the necessary length. Although the process is a slow one, it is far preferable to frequent mashing, and is much approved by those who practise it. Others defer sparging until one-half, three-fourths, or the whole of the first wort is run off; but it appears that a majority mash a second time, whether a sparger is used or not, and aver that the whole extract cannot be obtained by one mash and a sprinkling. Richardson was of this opinion, because he had not sufficient patience.

Most brewers must have observed, that during the drainage of the first wort, the goods settle down into the lower part of the tun, which settlement causes a circular chasm, sometimes of considerable depth, between the goods and the tun; and as the mashing-machine remains stationary within them, the lowering goods rest upon its shaft, and subside between that and its

numerous rakes, forming vacuities beneath them; and cracks and channels are formed in other parts of the goods, increasing in width or number according to the time engaged in drawing off the worts. Sparging upon goods in this state must be disadvantageous, in consequence of a partial drainage through these various soughs, fissures, and void spaces; therefore reparation is usually sought in a second mash, but can only be rendered of tolerable service by keeping the goods in a very fluid state during the after process of sparging. Difficult and unequal drainage is yet the more evident with gritty malts containing a superfluity of insoluble particles, which accumulate in strata, stop the pores of the mash, and create impervious masses, often causing the extracting liquor to shoot across the surface towards some hidden cavity, or to run off obliquely in currents to fill the chinks, instead of percolating directly and equally from top to bottom. This state of management cannot be otherwise than well known, and particularly to the porter brewer who mashes the patent malt with his other *grist*.

The author would be extremely sorry to disparage other men's measures, or unnecessarily to allude to any system pursued by any class of his brethren in the trade, his object being solely to point out the defects in the old practice, and to suggest a new and better course for the benefit of those who encourage the invention of improvements, leaving others to enjoy their own opinions at their own leisure; but he has only to turn to the London cow-keepers' men, and to ask them what they see and feel when throwing the grains out of some of the mash-tuns in the metropolitan breweries; and if then bound to believe what one-half of them say, he will find that they prefer those that lie under the mashing-machines and rack, and round the bottom of the upright

shaft; and he must thenceforward conclude that the mode hitherto followed, where every requisite which skill can devise, and which has apparently been adopted, is far from perfect; and that mishaps of a similar kind, but to a much greater extent, are of still more frequent occurrence where the operative brewers are destitute of the advantages possessed by the ingenious individuals who have the management of these tremendous establishments.

In many breweries, both in and out of London, recourse has been had not only to second, but to third, frequently fourth, and sometimes fifth mashes; but in the preceding chapter the Mashing Attemperator has been accredited for the whole as an entirely efficient instrument, and such it will ever be found; and it may hence be presumed that a devisal for exhausting the retained saccharine matter without extracting also the pernicious elements, will be at once productive of *economy*, *expedition*, and *security*.

These weighty desiderata the inventor of these machines has deeply considered throughout the arrangement of his plan, and especially in the aid and aim of the Hystricon, or continuous sparging, agitating, and grain-ejecting machine, which he has brought forth as a means of reducing labour, of saving time, and of diminishing expense; and has attached to each of his three points its order in the arrangement of the ideas proceeding from *cause*, *action*, and *effect;* and in that order they are here treated.

Before entering into a minute illustration of the mechanical parts and practical properties of this piece of mechanism, it may be proper to shew that once mashing, as already maintained, is sufficient to liquefy and unfold the saccharum of the malt. In this mode of treating the partially spent goods, the reader may perceive an

agreement in this respect with the Scotch method, where it is held that the whole extract should be made in the first mash, because all that is afterwards required is a mere washing out of the remnant left in the goods; and it is moreover observed by Mr. Black, that "those who go farther do more harm than good, as they only obtain mucilage, which instead of enriching, impoverishes the beer." Here, then, is an assertion which quite establishes an opinion entertained by the author, that though Mr. Black happened to be the first to point out the importance of the exertion of diastase through proper mashing heats; yet, being at a loss for the most efficacious means for increasing the heat of the mash, his dread of mucilage shews that he did not derive much benefit from his knowledge.

The inutility of a series of mashes with the same goods, seems generally to be known in Scotland, as we find another writer on this subject, arguing that as his countrymen mash but once, properly speaking, they cannot be said to have more than one wort, the first running of that wort being the extract obtained from the malt by the liquor used in the infusing process, besides a considerable portion of that which the sparging produces; the after running being entirely the result of the sparging operation. The sparger mentioned as being so generally used by the Scotch brewers, is now tolerably well known in England; but to the uninitiated it may be necessary to describe it. The apparatus consists of a perforated horizontal tube, resting upon a bar, and supported by a pin in the centre, above which and the tube a receiving vessel is placed, to supply the tube with liquor. The perforations extend through the whole length of the two or three arms of the tube, so that the sparging water may spout horizontally, but in the opposite directions; and the reaction generated by the

issuing of the water from these side holes, is sufficient to keep the pipe, by its centrifugal power, in a rotatory motion, dispersing the liquor equally over the goods. In short, this common sparger is a modification of the well-known and much-admired "Barker's Mill," and is another application of its principle. A well-founded objection has been made to this kind of sparger by a London brewer of high scientific attainments and most extensive practice, because of the water cooling too much on its passage to the goods; but this objection is removed in the Hystricon, which conveys its water in a close pipe directly through the sparger to the goods, which sparger nearly touches them during the whole operation. Its various bearings shall now be minutely considered.

I. Of economy or Cause.—Dugald Stewart has with justice observed, that the essence of the philosophy of Bacon and Newton consists entirely in "ascertaining the universality of a fact;" it will therefore be under the guidance of such philosophy, that an attempt shall be made to ascertain how far the inventor's statements, or those which he has chosen to adopt as his own, can be borne out. Now, the following simple experiment will prove that the brewer, by his present inefficient process, does not obtain all the saccharine matter which the malt is capable of yielding. If, after the extracting process is ended, 50 lbs. of grains be taken out of the tun from a few inches beneath the surface, the same from the centre, and a third equal weight from the bottom, and if each of these be subjected to further sprinkling with water of the same temperature and quantity, as two quarts, for instance, in each case, and if the first assay jar of wort imparted by each sample in its respective order be fairly weighed by the saccharometer, the three results will shew that the heaviest

and sweetest worts reside at the bottom, and the lightest and most insipid near the surface, the extract from the intermediate sample being proportionate in density to its distance from the extremes of height and depth; the gravity at the bottom being, for example, some 2 lbs., that at the middle 1·5, but that towards the top only 1 lb. or less. This difference will not be quite so apparent when the grains have previously been kept in a saturated state, or when a return wort has been drawn from them; for some brewers keep their goods standing, or rather swimming, in water, that they may realise a greater extract, and boast of it accordingly, regardless of the soundness of the constitution; but in the ordinary state of the mash-tun at this period, especially after repeated mashings and divers spargings, the comparative densities of the respective extracts will usually stand as above.

If, with the grains taken from the upper part, an additional experiment be made, the saccharometer will indicate but very little improvement in the water, and perhaps none. To practitioners the latter fact cannot be new, and they are equally well aware of the small quantity of water and time required for the removal of the saccharum from the grains nearest to the action of the sparger: this arises from the lightness and porosity of the surface, and from its being constantly washed by pure water only. On the knowledge of this important fact, the principal feature of this invention is founded; and it has this novelty at least, be it merit or not, that it removes the permanent surface of the goods, disposing of the tendencies consequent on such permanence, and creates a continuous light and porous surface or superstratum, treating it with a sufficiency of pure water from the commencement to the termination of its action, by a well-directed sparger, which cleanses every particle of

the grain, internally and externally, of all the saccharine and other fluid matter; but that other matter is arrested in its progress downwards, and the exhaustion throughout the whole mash becomes as complete as it has heretofore been in the upper strata only; and a considerable increase of extract is the result, besides other very important benefits, chiefly noticed under the third head below.

Every brewer is sensible of the inferiority of weak worts from party gyles, and many usually give a pound or two of saccharum *per* barrel on their ales, when under 20 lbs. *per* barrel, if drawn from the same goods as an article of greater strength. It is a fair presumption that this liberality on the part of such brewers, emanates from a conviction that their saccharometer presents a false indication of the actual density of the saccharine body of these weak ales, and that the instrument is affected by a foreign agent: he certainly ought not in anywise to do it from the apprehension that the individual saccharum of itself, and alone, is inferior in sweetness to the first extracts. The ales are inferior only in specific gravity and in richness or flavour, the most valuable constituents of which have evaporated or passed off with the first worts. The pound or two *per* barrel, then, must be given as compensation for the injurious effect of some uninvited attendant, or apparent "necessary evil," as it is called by some who calculate on a wrong basis, which evil has the effect of smothering, sooner or later, the most desirable qualities of the saccharum.

Other and very serious evils attend party gyles. There cannot be any real difficulty in working them, but there is a great doubt of their working satisfactorily when the worts differ in constitution; and there is much

trouble, some perplexing calculation, a great loss of time, and sometimes of material also, in obtaining any certain gravity requisite to sustain a given price.

Another matter requiring serious consideration, is that of return worts. Brewers of strong ale, economists of a certain class, and those whose peculiar trade and practice enforce the use of these worts, as well as persons who reject them, know too well that they have but a choice of evils. Amongst the latter ranks Levesque, who wisely observes, that though throwing away a wort of five or six pounds *per* barrel may seem extravagant, it is " like skimmed milk, but of little value." Thus one throws away that which another estimates at an equal proportionate value with his other worts; but in the new system such worts are unknown. The merits of these people's practices may be best illustrated by reference to the following common-place example:—

Of two successive 20 quarter brewings, the first shall produce a return wort for the second day's brewing, amounting to 36 barrels, at 5 lbs. *per* barrel, or $36 \times 5 = 180$ lbs., which being divided by 95, or the quantity that good malt will yield, gives nearly 1·9 quarter of malt, which at 65*s.* *per* quarter, amounts to 6*l.* 3*s.* 6*d.*; and supposing this to occur only once in each week, the loss exceeds 320*l.* *per annum.* This is undoubtedly extravagant, and the advocates of the wasting system content themselves with the declaration that it is next to valueless, which surely must signify, that although 36 barrels of wort contain 180 lbs. of fermentable matter, it so abounds with impurities, *through the manner in which it is extracted*, that they neutralise the benefits expected to be derived from any saccharum which it may contain, to such a degree, that the whole becomes no more valuable than the original water. Thus

we see that the consequence of such a practice is, that 5½ *per cent.* at least of the available saccharum of the malt, in every brewing where short lengths are drawn, is devoted to the feeding of pigs or cattle! This reduction of profit, with its concomitant disadvantages, has hitherto been in a great measure unavoidable, in consequence of the absence of proper means for the extension of the malting or saccharising process to the mash-tun, and for dividing the rich soluble properties of the malt from the poor and insoluble. But whether these return worts be milk without cream, or water without sugar, or worse than either,—or whether they be profitable or injurious, they need no longer be desired or feared, nor need party gyles be made; or if made, the coarsest and least soluble of the objectionable ingredients may be rejected by those who possess the new apparatus and apply it properly; and having thus far defined its economical principles, and shewn the causes of its necessity, it may now be advisable to describe the machine itself, with the manner of its operation.

II. Of Expedition or Action.—The saving of many *mashes* or *comminglings* is one act of expedition; and that of a protracted sparging (from *spargo*, to sprinkle), and a consequent economy and facile management in treating and separating the gyles (from Γυαλον, in English idiom *gyalon*, a cavity or pit), is another; since the sparged wort produced through the Hystricon (from Ὑστριξ, a porcupine or hedgehog, so called from the structure of its agitating rake), may be added to that originally produced by the mash, without any fear of the common consequences; but the action of this instrument itself is so expeditious and conclusive, that its use and title may be conjointly considered under this head as an indivisible and distinct subject, requiring the

greatest consideration: hence, then, this section on the use of

The Hystricon.

The period of setting tap having arrived, that must be done so as to draw off the wort as fine as possible, and if the Attemperator has been properly used, it cannot be otherwise than bright. The goods having parted with the first wort, or nearly so, they will have subsided beneath the rakeless part of the mashing-machine, so that from this period no part of the Mashing Attemperator touches even the surface of the mash. The power and machinery used for working the Attemperator will also work the Hystricon, and when put in motion, the momentum will be conveyed to every part of the apparatus, which combines the several advantages of a sparger, with the additional functions of a superficial grain agitator, a skimmer or conductor, and an ejector; and when these get into play, they will perform in the following order: the whole, when in revolution, proceeding round the tun, occupies at its outer end some fortieth part of the circumference, the inner being attached to the central shaft; it also fastens to the cross-bar, and revolves with it round the tun. The Hystricon is acted upon by a depressing screw, placed between the bottom of the vessel, and extending upwardly to reach the vehicle, which it draws into a downward motion, that applies conjointly with its other rotary and reciprocating actions; thus the front of the machine dips into the mashed grains, and the apparatus by its revolutions describes a spiral of uniform flexure round the central shaft, working its way from the original surface downwards, till it scrapes the bottom.

The conductor takes the lead, with its front edge

buried at the depth of about an inch below the surface of the grains, forcing them to ascend the inclined plane of its surface into the machine, where they are passed on and conducted by a metallic endless web to the centre of the tun. While the grains are in their transit towards their destination, the agitator follows close behind the conductor, but an inch or two deeper, disturbing the stratum of grains from their local rest; and the sparger follows in the rear, visiting these loosened goods with a searching shower of hot liquor, which completely purges them of their saccharum, and leaves them ready to be taken up by the collector.

During somewhere about the first ten minutes, as the Hystricon cannot lower itself till the screw is disengaged, which makes the time of preparation optional, only two parts of this compound machine will be engaged, which are the sparger and the agitator; and this time will be sufficient for the sparging liquor to cleanse the goods of their saccharum to the requisite depth, efficiently aided, as the drainage is, by the agitator, which being set with spikes, is of a porcupine-like construction, whence its title; for its duty is to revolve and vibrate all the while by an oscillatory motion, and by this motion to break the surface of the goods and make it light, so as to facilitate an equable drainage. The depressing screw being now disengaged, the conductor speedily comes into action, collecting the exhausted grains from the surface of the mash, and conveying them to the web, which carries them to the centre of the mash-tun, and thence they will gravitate and pass down the hollow shaft out of the way; but if the locality of the premises will not admit of their accumulation or immediate removal elsewhere, when passed down the centre of the mash-tun, and if it suit the general arrangement of the

plant better, they may be ejected by a simple contrivance, over the edge of the tun.

In due time after the first contact, that is, within two or three minutes, the skimmer again crosses the ground of action, and takes off the purged and now dry grains; as uniformly does the "*fretful porcupine*" agitate the new stratum exposed by its leader; and with the same punctuality the sparger continues to dash away the saccharum; and at the same time the whole apparatus accommodates itself to the decreasing bulk and lowering surface of the goods, until, by its various but united efforts, it has driven all the saccharum out of the grains, and all the grains, where convenient, out of the mash-tun, sweepings only excepted; when it will cease, and the process of extraction and expulsion will accordingly terminate.

1. It presents at every point, during the progress of its operation, a new artificial, light, pervious, and transient surface, continually depositing the yieldings of the goods within the substrata immediately beneath, in a rich saccharine fluid; purifying itself by filtration; and if the short space of time which passes while the machine performs a single revolution, will at all allow the surface to be partially oxygenated, it is immediately conveyed away beyond the reach of serious mischief, each portion of the changing surface being struck once by pure water, but not oftener, nor by any other agent.

2. The developement of the acidifying principle, commonly destructive in worts, is controlled by the operation which clarifies the wort, and the denser and cleaner it is, the more tenacious is it of its heat, and the more obstinately does it resist the insinuating and contaminating particles of the atmosphere.

Many collateral circumstances here require some at-

tention. The first of these is the position of the copper or hot liquor-back, and the nature of its connexion with the Hystricon, so as to give a *maximum* of power to the sparger. According to the principles of descent by gravitation, the application of an unbroken liquor-pipe from the copper to the sparger, converts the whole perpendicular height between them into one column of water, and causes the liquor to run out of the sparger with a velocity increased in proportion to such height, so that the higher the copper, the greater the velocity; and the extraordinary powers of the sparger itself must be evident, when it is known that its arm forms a part of the vibrating agitator, at the bottom part of which arm are the exit holes, which are constantly within a few inches of the goods, and emitting numerous commingled and intersectional jets of water, more or less perpendicular, which are shaken by brandishment to and fro upon the grains, while they are being turned over and kept in motion by the agitator: these uncommon arrangements, therefore, render the sparging universal and exceedingly potent; though less liquor, less time, and much more heat, will be engaged than heretofore, and the concentration of the produce will thereby be promoted.

The sparging liquor should never be colder than the first mash; for if so, the pores of the husk, hordein, &c., will contract, and the more sparingly will the malt part with its matter, then held in a state of solution. When the highly concentrated and hot condition in which the worts quit the mash-tun is considered, possessing as they assuredly do, in a corresponding degree, the preservative essentials which are purified by percolation through the kindred goods, these circumstances combine to prevent the danger of acidity. Add to this, that of course nearly all the extract will require dilution to reduce it to its proper density in the wort cop-

per or back, when a light article is demanded. In accordance with the principle of this theory, a hint may not be considered untimely. It will be found infinitely better to dilute with clear fresh water than with an impure wort, impregnated with nothing more or less than the germs of acetic acid, as all those weak and paltry worts are, after an ordinary *first* mashing process, and when obtained by the old method of repeated mashing.

On the contrary, the system naturally enforced by the application of the Hystricon dissolves and releases only a very small quantity of these objectionable ingredients from the malt, and even that quantity is rejected by the fluid, and has to accompany the grains; for by the arrangements already explained, the observant mind will perceive that the contents of the mash-tun, or bed of goods, will be sufficiently close and compact, and, with proper management, capable of performing the office of a filter; and in consequence of its pre-existence, its sweetness, &c., perhaps no filter can be devised that will perform its functions in shorter time, or with so little waste of caloric, odour, and saccharine matter.

Another singular and important benefit attending this management of the goods is their gradually increasing solidity throughout the period that a finer filtration is most essential. This preparative quality is created by the constant liberation and descent of minute particles of husk, acrospire, rootlet, albumen, and other fragments, from the surface, as they are beaten off by the agitator or coagulated by the hot liquor, so that as they gravitate, they take speedy possession of all crevices and interstices, and there accumulate as they descend, presenting from the base upwards a firm and quiescent obstacle to the progress of the minutest matter, and allowing little to flow away

besides bright liquid sugar, perfectly free from every impurity possible to be removed, which will occasion a greater saving of time and trouble in the future purification of the extract.

When the process of extraction is over, a slimy and gluten-like white sediment is deposited in considerable quantities on the perforated plates which form the false bottom of the mash-tun: these are, undoubtedly, the most objectionable part of the grist or malt, consisting of a great proportion of detached hordein and farinaceous and glutinous matter, but principally albumen and the like, such as the ancient brewer endeavoured to destroy by continued boiling. Notwithstanding that such viscid matter does not retain any of the valuable saccharum that has either separated from it or filtered through it, yet when diluted it affects the saccharometer to a considerable degree, amounting in some inferior malts to 2 or 3 lbs. *per* quarter; and were it practicable or desirable to separate the fluid saccharum and mucilage from the whole of their accompaniments, it is more than probable that the diminution of density would, in many instances, double the amount. Yet with this purposed and inevitable subtraction of weighable but worthless matter, the process yields a far greater extract than any other yet discovered, not to mention its superiority in every requisite quality.

With this explanation it would be superfluous farther to set forth the utility of the Hystricon, or its value as a machine, in contrast with the generally existing practice of the brewery, whether in consideration of quantity and quality of saccharine production, of concentration in the raw worts, of expedition and ease, or of general economy; and with respect to freedom from acidity, it will be found equally pre-eminent.

This introduces the third and last recommendation.

III. Of security or effect.—One of the principal calamities which is likely to befall the brewer, and one which, under the most favourable circumstances, always begets public disappointment and private injury, is the acidifying principle of the atmosphere. This is often particularly felt, to ruinous extent, in breweries where large quantities of table beer and return worts are made, and especially in warm weather, and when the extracting liquor is used without proper attention to its heat. In reference to this subject, the author hopes to be pardoned for the re-publication of the curious opinions advanced as principles by authors, many of them eminent, in the absence of such machines, and without the knowledge of such principles as he has defined. On a general comparison of those opinions, whether of practitioners or of theorists, they will be found to have sprung from various causes, but to agree in this main particular, that something has been wanted, although they have not known what, to counteract, or, more properly speaking, to postpone, the operation of those causes of acidity which are inherent in all fermented liquors brewed upon the old system: this, however, as is too well known, they have effected in a very limited and inadequate degree, as well they might, when without a basis whereupon to found their thoughts; but this has not rendered them the less entertaining as a collective view of the errors of mankind in this beautifully practical department of theoretical art.

1. Levesque.—"The brewer should carefully clear off the grains immediately after the last mash is drawn off, for if allowed to remain, they will certainly do serious mischief, as they will soon ferment and *strike an acid into the wood;* and the latent heat of the mash will also spend itself, and impart a degree of acidity into the malt by the stagnation of the heat." (p. 38.)

2. Shannon.—"I think it necessary here to advert to the manner that some gentlemen in the trade have recommended to dispose of the superfluities of the fourth mash, which is, to use it instead of so much liquor in the brewing of the succeeding day. I have only to observe that this has been the practice of the malt distiller for many years, and with him it is unexceptionable; but when it is considered that it is always a weak, and generally a liquor of an acid tendency, the impropriety and even danger of using it in brewing beer or ale must be apparent with respect to *hastening the decline* of such beer. It will certainly suit a vinegar maker, whose object is acidity, and may be used with impunity by the malt distiller; but let the porter and ale brewer beware how he risks his future gyle in this way; and let them who make a practice of it account in future for their redundance of stale beer, and many other intruding inconveniences they were hitherto at a loss to account for." (p. 288.)

3. Baverstock.—"A studious observation of the powerfully different effects of the different degrees of heat in the water used in the several extractions, and of the heat in fermenting the worts so extracted from the malt, is of the very first importance and necessity. The last is an operation of such influence in the case, that in conjunction with the precautions required to be observed in the mashings, fermentation determines the early or the latter period of natural fineness, as well as a distinction of flavour, according to the several stages of its progress, and fixes the principles of preservation in beers. Hops afford the basis of this last mentioned and desirable property; but *all the benefits of the hops are destroyed by a few hours only of too long protracted fermentation.*" (p. 129.) "Fermentation, besides the principal action of converting the sweet of the worts

into vinous spirit, as well as producing other useful effects, determines the wholesomeness or unwholesomeness of malt liquors." (p. 241.)

4. DONOVAN.—"*Length of time in mashing will compensate for* coarse grinding; but *delays* are particularly dangerous in brewing; and often *to them* may be attributed the commencement of sourness, which has ultimately destroyed the produce." (p. 147.)

5. COMBRUNE.—"In brewing with one copper, scarcely more than *three* mashes can be made; otherwise the time taken up in boiling the worts and preparing the subsequent waters for extraction, would be so long as to cause the grist to lose great part of its heat; and in warm weather, perhaps, to become sour." (p. 235.) "In proportion as it is brewed *in a hot or in a cold season*, we must employ every means either to repel or to attract the acids circulating in the air."

6. ROBERTS.—"It is of consequence that *the surface of the mash should not be exposed* to the atmosphere, as the goods are very apt, especially in warm weather, to acetify from the imbibing of oxygen. I am of opinion that acetification has often taken place through want of this precaution, and am inclined to think, were brewers more generally to take this into consideration, and act accordingly, they would not run the risk of incurring so much loss as they now do by the frequent return of sour or hard ale." (p. 90.)

7. HAYMAN.—"The constituted principles of malt are known to be chiefly salts and oils; the first of these tending strongly to fermentation, requires a proportion of the latter to restrain its powers, without which those qualities for which the best of our malt liquors are admired, namely, softness and spirituosity, would be destroyed; consequently, the great object to be obtained in brewing is *so to regulate the heats* of the

liquor as to extract a sufficient quantity of the oils to counterbalance the effects of the salts." (p. 8.)

8. THOMSON.—This eminent chemist, alluding to the series of experiments made by the Scotch commissioners on a large scale in some papers presented to the House of Commons, says, "The proportion of starch was usually greatest in the first worts, while that of the mucilage was greatest in those last drawn. The saccharine matter also diminishes sensibly towards the end, and at last disappears altogether. *The last portions of wort become much more easily acid* than the first, and, indeed, often taste sour, even when running from the malt." (Donovan, p. 152.)

9. HAM.—"The proportion of the starch sugar is generally the most abundant in the first runnings from the malt, for when two or three subsequent mashings are employed, the water dissolves with this saccharine matter a proportion of *mucilage and gluten, which causes the wort therefrom to turn acid* much quicker than the first wort. The mode of brewing here recommended, (sparging after the first mash,) will avoid this additional extraction and consequent tendency to acidity in the future beer; and although the total extract from the malt is rather lessened thereby, little is left behind but what is likely to injure the future quality of the beer, and to render it thinner and harsher to the taste; and if brewers were in general aware of this effect, they would pause before they attempted to extract the utmost possible quantity of soluble matter from the malt." (p. 11.)

Now, whosesoever theory in this edifying and amusing catalogue is most worthy of regard, or if each be received as a portion of a stupendous whole, (for they all contain much truth,) this certain conclusion is evident, that too many mashings and sprinklings deteriorate the beverage, and subject it to acidity; but,

curiously enough, the Hystricon provides an universal antidote in all cases or varieties of shape into which this contrariety of expression can be ramified and made to diverge. Agreeing with Levesque, that grains turn sour by standing, and knowing, moreover, that the directors of a certain establishment, not far from Birmingham, were but a few years ago put to the expense of a new twenty-five quarters mash-tun from the same assignable cause, this invention precludes the possibility of a recurrence, by emptying the tun as it proceeds.

Shannon's precaution against return worts is also taken here, because we have nothing of the kind, and Baverstock's and Donovan's dread of delay falls to nothing, besides which, the concentrated and brilliant worts produced by the machinery are fitted for fermentation in a peculiar manner, and are less liable to become acid than those of a less stable kind; besides which, the Attemperator secures a sound heat which has no fickleness, and the surface is unexposed to the atmosphere for any length of time during the sparsion. Roberts's objection is also met; as is likewise Combrune's, as far as regards repulsion, and as consistent with general theory. Hayman's distribution of the constituents of malt into oils and salts is less definite than the rest, yet it admits of a kindred interpretation; and he elsewhere says that where malt contains little saccharine matter in proportion to the other products, "the beer brewed from it is vapid and poor, and turns acid in warm weather, and it injures the reputation and pocket of the brewer;" thereby, in common with the rest, completely advocating a new system by protesting against the old. Thomson's experiments strongly favour the invention, inasmuch as they prove that the mucilaginous matter does not begin to flow freely till the saccharine principle is waning; and besides this, mucilage undergoes a further change by virtue of the requi-

site time and temperature in the first mash, for it becomes a sweet. Hence to protract a brewing by repeated mashes is erroneous, because they are destructive of the nutritious property. Lastly, Ham's declaration against extracting the "utmost possible quantity of soluble matter" is no longer serviceable, because the mode of procedure has assumed a new measure and shape, in which the objectionable ingredients are either suppressed, converted, or rejected, and a more valuable commodity, heretofore unreachable, is by conversion obtained in lieu; for whatever the Mashing Attemperator leaves undone, to which utility can give a sanction, the Hystricon is constructed expressly to accomplish; for as Dr. Shannon again says, in his second book, page 11, and of which these pages must convince every steady reader, "distinctively, the saccharine principle is productive of the vinous, the gluten of the putrid, and the mucilage of the acetous fermentation."

So that whether the principle of acidity in raw worts be attributed to a tardy process, or to oxidising the surface of the mash, or to the quality of the extracts unitedly, or separately, (but unitedly of course by concatenation,) or to any other means which has hitherto been assigned, the Hystricon has its cause in economy, its action in expedition, and its effect in security. With such a mass of evidence in its favour, and such a host of witnesses to pour it out spontaneously before us, none of whom could have any self-interest to subserve, we must either question the competency of talent to judge, or we must admit the validity of the proofs which these individuals have adduced; for justly the poet asks

"How or why
Should all conspire to cheat us with a lie?"

One objection, and that the only one which can be

reasonably made against the introduction of the Hystricon, is its cost, coupled with the danger of placing it in the hands of novices. As concerns the mash-tun, the Mashing Attemperator is certainly the more valuable of the two inventions, because of its extreme simplicity and its converting and concentrating powers; and experience soon assures all who use this machine, that many of the advantages derivable from the Hystricon alone, may be obtained, *after the first mash is properly made*, by a careful and well-informed practitioner; and these are a truly bright and extremely dense and rich extract of any weight within reason, in one wort only, forming a much greater amount of extract than can by any possibility be produced by any other known means.

Having disposed of this part of the subject, in doing which the grains have been neglected since the moment that the web ceremoniously but promptly conducted them out of the tun, let us recollect that the destiny and remembrance of these our *quondam* friends are too interesting for oblivion, and too lucrative in their aggregate to be despised. Dr. Ure treats this subject in his Dictionary of Arts, &c., with singular benevolence to the brute creation, where he condemns the practice of a triple mashing operation, because he thinks that it exhausts the malt till the extract is not useful for *strong* beer or porter. He admits that a weaker wort *might* be drawn off for small beer, "or for contributing a little to the strength of the next mashing of fresh malt" as a return wort; but instead of shewing chemically that such a practice would or would not answer, he contents himself with the belief that respectable brewers seldom employ it in that manner, as it impoverishes the grains, which are useful as food for cattle. Verily "respectable brewers," if of the thoughtful class, have much more cogent reasons than this

The author having expressed his sentiments on this subject rather freely, and he hopes convincingly, would not have referred to the above curious excuse for the waste of a little fattening extract, had not such superficial logic a tendency to mislead capitalists and to shackle the energies of the wealth creators, namely, practical and scientific men, had he not heard of pigs made drunk with brewers' refuse, and had not a similar but silly and uncommercial observation been made to him as inventor of the Hystricon by one of the directors of a brewing company in Birmingham, who after witnessing and admiring the splendid action and decisive exhausting powers of this instrument, was doubtful whether the depreciation in the quality of the grains would be compensated by the additional extract obtained in consequence of such exhaustion of the malt! Let the practical brewer answer these two questions—Does not the price of grains depend more upon the supply and demand than upon their quality? Which, during the progress of extraction, is the brewer's greatest care, the enriching and increasing of his worts, regardless of the poverty that he inflicts upon his grains, or the thought of converting grains into money? This subject, he is persuaded, would hardly be worth disputing, in these days of competition and scrambling for gain, did it not afford an excuse for an anecdote or two. A friend, in the firm of a celebrated brewery, has ridiculed this idea of rejecting an additional profit of from £800 to £1000 a year, by the "visionary wiseacre," for the sake of retaining an income of £250 which may still be realised; and has observed that it has reminded him of an old gentleman in the country, who was well known to the informant's late partner, and who kept many swine, which were his chief hobby. When the breweries did not furnish a sufficient supply of grains

for the old gentleman's purpose, he would say, "Well! my pigs must not want.—Grains they must have, if I brew on purpose and spoil the drink, which I always do!" Another intimate friend, a manufacturer, observes upon the same subject, that if the increase of scrap, or waste metal, when the cutting-out tools have been employed, indicates judgment and economy, he will order that fewer goods and more scrap be made forthwith; and a third facetiously says that the whole argument brings to his recollection the poor Roscommoner, who after reposing on a bed of straw in England, exclaimed after an exultant sneer at the English straw, that it was not half so good as that of his own country, it was thrashed so cruelly.

Grains are properly called "*draff*" in the northern English counties, because the strength has been *draughted* out of them; but draff will still be draff in quantity, to whatever extent it may have been draughted; and in consequence of his own experience and that of the several establishments where his apparatus has been tested, the author has no respect for the philosophic cunning of those financiers who tell him that he washes every thing out of the husk, whether bad or good, and therefore are fearful that his extract contains "too much *gluten* to keep:" an observation which refutes itself, and shews that they who employ it have not learnt their lesson. Nevertheless, the grains that are left after having been operated upon by the Mashing Attemperator and the Hystricon, are too remarkable in their structure to be thrown away without notice; for on examining them, the fleshy parts of the farina, which constitutes the chief value of the draff as food for hogs, is found adhering to the husk, and constitutes that which chemists term hordein, being a farinaceous substance too obdu-

rate for conversion into starch, probably from the imperfection of the seed, since in some husks the appearance of empty honeycomb is presented by the microscope, the cavities of which are numerous, and are deeper at the end which has connected the skin with the farina which has dissolved away from it in the mash: indeed, the ragged appearance of these grains is more or less perceptible in every house, but is more particularly observable in the undissolved portion of the grain that has been operated upon by a judicious use of the Attemperator. Even during the first mash, before the sparging has commenced, the adhering farina feels softer, and appears more spongy, than when brewed by the ordinary process; and the conclusion to be formed from this striking fact is, that the gluten, &c., has, through the long continuance of a suitable heat, released its cementing hold upon the particles of the farina, and has thus opened a free passage for the solvent power of the liberated diastase, and the assimilating property of the saccharum to and on the starch and more matured parts of the hordein, there enveloped by the more hardy portion, and by the less soluble and fibrous, or lignine parts of the grain; which is probably the chief cause of the gradual increase of convertible extract, and of the consequent improvement in the density of the wort.

Circumstances may arise in life, of such a character that a person feels himself so placed that he must not only take common care of himself, but also act as a monitor for the sake of others; and such happens to be the author's own situation, at least so he is persuaded, while pursuing the unoffending course which he had prescribed for his own guidance, in bringing his inventions before the public. A fellow, adverted to in the former edition of this work, issued a circular in the

summer of 1844, in which he undertakes to work miracles such as never entered the brewery. Not content with joining Shannon's and Black's principles into an assumed system of his own, though clearly pirated from them, he professes to produce, "in two hours,"—"great gravities"—"by this means,"—"which it would be *impossible* to obtain *by any other*,"—"varying from ninety to one hundred and ten pounds *per* quarter of malt;"—neither is this all; for in some of his communications he pretends to extract 137 lbs. as shewn by his official circular. "*Official*" it must be, as long as the old bird remains in town and his emissaries move about the country like Guineamen or other slave-catchers on a barbarian shore, of course where their coast is clearest from shrewd intelligence and natural activity; yet, however secretly the traffic may be carried on, and how credulous soever the unwary may be, the privateer may chance to catch a tomahawking from a native, notwithstanding his craft and cargo; and it becomes an act of justice and kindness to put the public upon their guard against any leagued impostors who, with uncommon ingenuity in all manœuvres and platoonery, except such as belong to a knowledge of the art which they presume to spread, have the effrontery to tell brewers how to realise the enormous extracts above mentioned. The principal, from his town residence, refers his dupes to his coadjutors, who, wherever they happen to sojourn, represent themselves to be resident brewers in country towns, always, as a matter of business, at a respectful distance from parties applying for information.

Now, a quarter of tolerably good malt has been found to weigh about 320 lbs.; therefore assuming this as an example, and supposing it possible to convert the whole of the farinaceous matter into saccharum, leaving only

the outward skin or husk, which when dried to the same siccous state as its parent malt, will not be less than 28 lbs. and may be 48 or 68 lbs., and was estimated at 120 lbs. when Richardson drew his "Statical Estimates;" then dividing the highest possible remainder, 292 lbs. by 2·583, which is the dry extract that produces a pound of density by Long's or Bate's saccharometer, the quotient is 113·047 lbs. *per* quarter, as the utmost density that such good malt can yield, when the husk is exhausted by machinery till its interior becomes like honeycomb as above described.

The fallacy of these pretenders is still more striking if we imagine the possibility of dissolving every part of the malt, husk included, into wort; for the 2·583d part of 320 lbs. is 123·827 lbs., whereas they profess to brew 14 lbs. more, and if they employ the Scotch saccharometer, they will find themselves miserably more deficient; so marvellously clever are these ubique creatures of character and generalship, though they assuredly have not *yet* found how to brew all their grains into saccharine extract. Either they mean this, or their meaning is ambiguous; and if not this, they must analogically insinuate that 137 lbs. is their total extract *per* quarter, which is ridiculous, because an obtainment of 90 in indicated gravity is equivalent to a specific extract of 232½ nearly. One practical gentleman has wound up his correspondence with the parties by the following letter; and it is needless to say that the worthies found it too explicit to require an answer.

"August 28, 1844.

"In your reply to my last letter, you state that I have no confidence in you, and farther assert that I want to obtain all the information I can without paying for it: the latter charge I utterly deny, and whatever

'want of confidence' I might have shewn, the cause of it rests with yourself.

"You offer your services to brewers, to instruct them how to obtain something like 138 lbs. gravity by Dring and Fage from one quarter of malt: this being at least 40 *per cent.* more than I ever knew how to obtain, I was anxious to possess such *very valuable information;* but strongly doubting your ability of getting any thing like such an extract, I required a reference to some respectable party where your plans were now being used and regularly adopted. With this request I supposed you had complied when you instructed me to refer to Mr. W. B., of Southampton; but on enquiry I found that Mr. B. was only known in the town of Southampton as a temporary lodger at the house of an elderly woman in Bevis Street, and certainly *not known there as a brewer.* Not feeling satisfied with this reference, I requested you to favour me with another, and in this instance you referred me to 'T. P. *Esquire*, Englefield Green, Egham, Surrey:'—here again I was disappointed to find the gentleman, as in the former case, just at that time to be out of business, and only known at Englefield as a resident with his father-in-law. What he may be elsewhere, I had no means of ascertaining.

"Now, sir, I will not question the respectability or integrity of these parties, but reverse our cases for one moment, and tell me as a man of business and experience, if these references would have satisfied you. The answer you must give is too palpable to be questioned. Upon my second failure, I remembered Mr. B. having told me in his letter that it was in Worcestershire he had 'followed out your plans,' being at the time 'a partner in an extensive concern,' and thinking it probable that there at least I should find your system in full vigour, I asked him to favour me with the

name of the brewery and its situation, but I judge by his silence that I have been too inquisitive.

"I will once more repeat my former question. Can you refer me to any brewer in England who is now using your plans? Will you name the breweries where Messrs. B. and P. used them? If it is not giving you too much trouble, I will thank you to give me the result of one of your own brewings, expressed in round numbers of barrels drawn, and density *per* barrel by Dring and Fage's saccharometer. To elucidate the sort of calculation I wish to be furnished with, I will suppose a case where you have been fortunate enough to obtain a gravity of 138 lbs. *per* quarter, say a ten-quarter brewing, first wort 30 bals. at 35 lbs. *per* bal.; second wort 30 bals. at 11 lbs. *per* bal., $30 \times 35 = 1050$, and $30 \times 11 = 330$, making in the whole 1380 lbs.; divide this by the number of quarters, and it just gives 138 lbs. gravity *per* quarter. The extract in a barrel of wort of 35 lbs. gravity, as shewn by Dring and Fage, is 88·4, and in a barrel of 11 lbs. gravity 27·7; to obtain the total extract, I multiply each of these sums by 30, being the number of barrels in each wort; $88{\cdot}4 \times 30 = 2652$, and $27{\cdot}7 \times 30 = 831$, thus shewing the total weight of extract to be 3483 lbs. from the 10 quarters of malt, 348·3 lbs. *per* quarter.

"If there is any error in this computation, please to point it out, state the weight *per* quarter of your malt, also the grains when dried to the same degree. Remember I am still willing to adopt your plans when reasonably satisfied of their correctness."

CHAPTER VII.

SACCHAROMETRY.

MANAGEMENT—THE LEICESTER SCREW—GRAVITY AND DENSITY—ORIGIN, HISTORY, AND USE OF INSTRUMENTS—HYDROMETICS—DICAS—DRING AND FAGE—THE IMPERIAL ACT—ALLAN—SCOTCH AND ENGLISH EXCISE—BATE—LONG—COMPARISON OF GAUGES—EGREGIOUS ERRORS—DOCTRINE OF EXPANSIONS—NEW UNIVERSAL THEOREM—DEDUCTIONS.

Of all the instruments that have been invented to assist the brewer and improve his practice, none exceeds the saccharometer in utility and elegance; and yet, though introduced now more than half a century, repeatedly improved, and vended by at least half a dozen eminent mathematical instrument makers, scores of brewers in the provinces never heard of its existence, and many others remain ignorant of the value of its application. Such is the apathy and dogged content under which some persons sleep, that though the light of science may smile upon them in the advice which they receive from some malt or hop factor, and though they may be induced to send to town for one of these instruments, which will arrive accompanied by a pamphlet replete with instructions and examples minutely wrought, and explicit enough to be comprehended by the dullest capacity, yet when the proprietor places it in the hand of his brewer, who probably is one of those who occupy the offices of stoker and cellarman to boot, for the munificent remuneration of some 20 or 25 shillings a week, it is returned upon the

master's hands without having been wetted, with an anxious wish for the safety of a bauble so delicate, and yet so troublesome and unserviceable to him; for, to tell the truth, John is like the Yorkshireman in the farce, who cannot read writing or print, though "a dab at chalk," and consequently, as it will neither increase nor improve the beer, he can continue to do without it, and it is consigned to the mantel-shelf as an artificial curiosity. The author has known several cases of this kind, and has had proprietors remarking to him that their business, from the smallness of its profits, was not worth their attention. Little dream they where the fault really lies, and little do they suspect that their hebdomadal pound's worth of ignorance costs them more than all their other expenses; for whence, it may be asked, originate the profit and success of an establishment if not through the managing brewer? ALL is based upon his understanding, judgment, and prudence; and his physical energies can avail but little, unless directed by wisdom and cultivation commensurate with the magnitude and importance of their engagement. For gentlemen to trust their reputation and capital, and perhaps their whole fortune, to the management of a brewer whose thermometer is his finger and whose saccharometer is his palate, is to adventure upon a strange sea with an insane pilot; or, as a once popular writer on the art was pleased to observe, every practitioner was involved in such darkness before the discovery of the instruments, that they were all placed on a level, and the whole process was as well conducted by any obscure and ignorant labourer as by his principal. He does not dispute that good beer was sometimes made; but then, it was not without a profuse waste of malt, hops, and time, to remedy the absence of system. As well,

says he, might a country bargeman be entrusted to conduct a vessel across the ocean to any particular port, without knowing the use of the compass.

The course pursued by men who work without instruments, is to make a certain length from a known quantity of malt, and if the strength appear to be there or thereabouts, well; but if not, to add another sack or two next time. They know not what advantage to take of a good specimen of malt, nor to make up the deficiency arising from inordinary badness; so that whether it be bad or good, the quality is of little consequence to them when the mash is in the tun. In short, such men have been known to lose 10, 15, and even 20 *per cent.* of the absolute produce which the malt would have yielded in skilful hands; and it is but a fair presumption that the like deficiency is of common occurrence; besides the uncertainty in which such persons are placed in judging of comparative quality in malt, which sometimes varies as much as 20 *per cent.* in quantity of extract, and *very* frequently not less than 7 *per cent.*; neither can they judge correctly of the gravity of their worts or the progress of their fermentations; so that the true art and most interesting portion of their avocation is no more than stupid and monotonous drudgery; whereas the intellectual man, who can use his instruments and estimate the value of his produce, walks in the light, sees his way, and is satisfied as he proceeds, ascertaining and fixing to a fraction the value of each separate quarter brewed, pitching his worts at an uniform or other exact weight and heat, regulating his attenuations to the nicest point, and thus by working systematically, founding and maintaining a character to his productions, and ensuring satisfaction and perspicuity at home and abroad, while his business

affords him a constant source of meditation and experimental recreation, at once instructive, interesting, profitable, and amusing.

Notwithstanding the accuracy and pleasure which sensible men necessarily derive from the benefit of a correct instrument, there yet remain some capricious individuals whose wretched knowledge of business is perplexing to the operative brewer who understands his duty and is desirous to perform it, and the following is an instance in point. Within the ancient and enterprising borough of Leicester lived a certain opulent grocer, who brought up a son to his own trade; but when the youth had reached maturity, disdaining a life of confinement behind the counter, and conceiving a notion that brewing was lucrative, he invested his property in a neighbouring establishment, engaged a manager to whom he delegated one rein, and held the other in his own hand, with which he intended to drive on so dextrously and mysteriously as to keep the hireling in ignorance of his densities and profits; but not being aware that malts, like sugars, vary in quality, he gratified his own vanity by prescribing to himself a definite quantity of barrels to a given number of quarters. The brewer, finding some of the worts greatly deficient, expostulated and complained that the gravity was too low, on which the master flew into a violent rage, declaring that his profits should not be controlled by any instrument or criterion whatever, and protesting against the use of so foolish a thing as a saccharometer.

The following is extracted from a letter written by the manager immediately after a final rupture between the parties. "'Will you,' said my employer, 'give me your word upon the honour of a man, that you will not use the saccharometer any more, nor allow it to be

used? for I am determined from this time that no brewer shall know the gravity of my ales.' I asked him how he could expect the attenuation to be properly conducted. 'As to that,' replied he, 'I care not a fig; it may take its chance as others do, for that is my determination, and unless you comply I will have nothing more to do with you.' My answer was, 'I shall do no such thing; and as I know your meaning, I shall certainly leave your employ.' That I did, although in the midst of a brewing of ale. This, you will see, arose from my pointing out to him one great cause of the decrease in our business; but you will not be surprised at any thing when I tell you that my extract was often upwards of 80 lbs. *per* quarter; but to such lengths was I compelled to run, that for six months together my best gyles did not exceed 24 lbs. *per* barrel, and very often less. You are at liberty to make any use you please of the above, as it is true to the very letter." The letter is easily answered: Gotham, not far from Leicester, is notorious for wisdom, and the gent. had been there.

Saccharometry, or the means of determining the true value of wort by its density, though now brought by practice to great perfection, has generally been considered intricate, as a subject more mathematical than chemical in its nature and dealing, and has therefore been less satisfactorily and effectually explained. The words *gravity* and *density* in worts, and in general, are by some used consignificantly; but on this topic, and on the means of ascertaining their intrinsic reality, and its value in the market, something definite requires to be said. *Gravity*, (from *gravis*, deep or heavy, whence *grave*, *gravy*, and the like,) is the absolute weight of a body when submitted to comparison with a known standard medium, such as air or water in a certain

state, and may be otherwise called *barosity;* and *specific gravity* is the relation which the weight of one body bears in proportion to that of another of the same bulk, or occupying an equal quantity of space; but *density*, or the accumulation of fermentable matter within the body of the liquor, (from *densus*, thick or full,) signifies closeness, and is the degree of compactness existing between the particles of the same body, without reference to any other; so that density is the property on which gravity is reliant.

The *hydrometer* or water-gauge, which laid the foundation of saccharometry, has been in use now nearly a century. The inventor was Martin, the Fleet-street mathematician, of whom Baverstock purchased one in 1768; but Martin himself tried it with beers instead of worts; and as their gravity depended on the degree of attenuation they had undergone, as well as on their comparative ripeness and clearness, he was so bewildered in his experiments that he gave up the pursuit. Mr. Whitbread, founder of the Chiswell-street brewery, was consulted, and thought as lightly of the invention as Martin had been led to do by his own ignorance of its proper application; but the celebrated Thrale, of London-bridge, who was persuaded by Baverstock to test his worts with it, which he did by a course of experiments made in the presence of Dr. Johnson, at once saw its merits and gave it his cordial approbation. Martin was improved upon by Quin and others, and Quin's instruments had been several years in use in 1785, when Troughton stood as high as any, both for finish and a correct index; and about the same period, Richardson, of Windsor, had the merit of constructing an instrument with a scale expressly calculated to shew the excess of gravity possessed by a barrel of wort or other examen over the same quantity of water; and as

this increase was supposed to be all saccharine matter, he gave the instrument the title of saccharometer. Harris, brewer at Combe's, also brought out an instrument which shewed the specific gravity of a fluid by a scale engraven on its stem ; and the instructions which now accompany Bate's government saccharometer, say that the tardiness of experimenting with the weighing bottle, led to the introduction of an instrument the reverse of the bottle, which by the addition of weights placed upon it, was made "to sink to the same depths in other liquids, and thus always displaced an equal bulk or measure of each liquid: this instrument is named a *gravimeter*."

The next to claim attention was Dicas, of Liverpool, whose instrument was of this floating kind, and "shews the quantity of solid extract held in solution, and is lighter than water." His principle was, that the larger the bulb or ball of the instrument, the more correct its indications would be; and this observation led to Dring's improvement on Richardson's principle. The art of saccharometry had then arrived at such exquisite nicety, that a tenth of a grain was expected to turn a balance loaden with 1500 or 1600 grains at each end; and Dicas's scale especially was "so very delicate that it required an extremely nice balance to weigh the instrument." It was also found necessary, when using Dring's instrument, to be scrupulously particular in keeping both it and its weights perfectly clean and dry; because when used in those establishments where large quantities of strong worts were drawn, a viscid substance was found to cohere, which affected their future accuracy.

Dicas's hydrometer shewed the number of pounds of extract contained in a barrel of wort, each pound being estimated to occupy ·06 parts of a gallon of the water,

whereas Quin's, Richardson's, and Dring's, merely shewed the additional gravity in a barrel of wort, caused by the difference of weight between the extract and the water displaced, slightly differing in their indications; but averaging the three, each pound of gravity additional to that of water, indicated the existence of 2·6 lbs. of extract, according to Dicas's rule: thus, a wort of 36 lbs. *per* barrel, above 1000 ounces to the foot, was calculated to contain 78 lbs. of saccharine extract, as exhibited by Dicas. In this way the saccharometer became a separate instrument from the hydrometer, which became a spirit metre, and was improved by Sykes in a material degree, till by an Act of 58 Geo. III., the standard of proof spirit was fixed at 923·08 by this instrument at a temperature of 50°, or at 919 at 60° by Fahrenheit's scale.

In 1805, a commission was issued for regulating the Scotch excise, and the members were examined before the House of Commons, and made a long report of their proceedings, from which Dring and Fage drew some practical hints, which led to considerable improvement in their mode of manufacture. They have two *poises* to their instrument, one adjusted to gravities varying from 20 to 40 lbs., and the other to those between 40 and 60, such as are under 20 being declared by the bare stem, the principle of action being this, that if a barrel of water (old measure) weighs 367 lbs., a barrel of wort in which the saccharometer floats at 20 on the side engraved 0, will weigh 387 lbs., and the No. 1 weight, when put upon the instrument in the same wort, will sink it to the upper division marked 20 on the side of the stem marked 1. Booth, who wrote the brewing treatise for the "Society for diffusing Useful Knowledge," referred to at page 114, chapter IV., observes, that in order to reduce Richardson's or Dring and Fage's

indications to the proportion of 1000, we must multiply by $2\frac{7}{9}$, because 1000 is $2\frac{7}{9}$ times 360, which is the weight of an imperial barrel of water in pounds; but Drs. Hope and Coventry, who were employed with Dr. Thomson by the Scotch Commissioners to experiment, came to the singular and ridiculous conclusion, that *by trial* they transferred Dring and Fage's indications into the language of specific gravity by multiplying the degrees under 12 by 3, and those above by 2·75, which bungling they were content to term "sufficient accuracy." Upon this they reported that the common saccharometers did not precisely denote the *attenuation*, properly so called, but were all constructed on the principle that each degree on their scale should indicate a certain quantity of weightier matter contained in a given measure of wort; but that none of them exhibited the real specific gravity, nor yet the change that took place in it. Accordingly Dring and Fage set their wits to work anew; but it appears that it was not till 1834 that they published a prospectus, in which they declared that all those errors were removed in the instrument which they then recommended, and which they had adapted to the imperial standard.

It may here be necessary to explain that the imperial act is that of the 5th of Geo. IV., chap. 74, dated 17th June, 1824, and denominated "An Act for ascertaining and establishing uniformity of weights and measures," which provides in the 6th section, that "the gallon shall contain ten pounds avoirdupois weight of *distilled* water weighed in air, at the temperature of 62° of Fahrenheit's thermometer, the barometer being at 30 inches." By the 5th section, the cubic inch is declared to be equal to 252·458 grains, at the same atmospheric pressure and temperature; by the 4th, the pound troy is fixed at 5760 grains, and the pound avoirdupois at 7000; and

by the 14th, which confirms the standard gallon at 10 lbs., its capacity is made to be 277·274 inches. This enactment is quite correctly estimated in one sense, because $277{\cdot}274 \times 252{\cdot}458 = 70{,}000$; but in another view it is doubtful how far the framers of the bill acted philosophically, because, according to this arrangement, the cubic foot of distilled water, without any reference to the convenient and well-attested principles of philosophy, is hereby reduced to $252{\cdot}458 \times 1728 = 436{,}247$ grains, which, at 7000 to the pound, are 62·321 pounds, or only 997·136 ounces instead of 1000. But we must not conclude, if legislators make erroneous calculations, that philosophy is untrue, and science a farce. The imperial measure is wrong only in estimating the number of grains that arbitrarily make a cubic inch; for if we consider that each ounce is equal to 1·728 inch, then the gallon of 10 lbs. or 160 oz. is 276·48 inches; and, on the other hand, 437½ grains being an ounce avoirdupois, 437,500 grains are in this instance a foot, and its 1728th part is 253·183 grains, or a cubic inch; so that by assuming this as a correct division of the imperial gallon, the product of these, or $276{\cdot}48 \times 253{\cdot}183 = 70{,}000$ grains to the gallon, as before. Sir G. Shuckburgh's experiments on highly distilled water, as published in the Philosophical Transactions, give 252·525 grains to the inch, which is between the imperial standard and that of philosophers. This is independent of the trivial difference occasioned in the density of a fluid by a change of temperature from 60° to 62° (about 0·2), which is nothing in comparison with other discrepancies presented in the practice of saccharometry.

Again, Dr. Thomson, at page 79 of his Chemistry, Vol. III., gives 1000 as the specific gravity of water at 60° F., and at page 193, says that Thames water weighs 1000·043, and that of the Clyde 1000·024; and we are

informed by the "Scottish ale-brewer" that nine-tenths of the Edinburgh brewers have their works on the lower ridge of the Canongate, and either have wells of their own, or are supplied by the Crawley water, which is brought from the Pentland hills in large iron pipes; and that though it is spring water, it is of fine flavour, but not softer, we may presume, than the running Clyde: but the Scotch calculators found heavier water than this; for admitting the principle laid down by Dicas, that each pound of extract occupied ·06 of a gallon, they took as an example 369 lbs. of water, at 10¼ lbs. *per* gallon, and added 78 lbs. of extract, which they thought would displace 4·68 gallons of water, leaving 31·32 gallons, or, as they say, 321 lbs., and with the sugar 399 lbs., which therefore would give an excess in gravity of 30 lbs. by Dring and Fage, instead of the absolute addition of 78 lbs. of sugar; but why they assumed 399 lbs., when the old gallon of water weighed no more than 367 lbs., and why they estimated it at 10¼ lbs. to the gallon, when it was an ounce less, they leave unexplained. Not being in a position to confess the palpability of their own errors, they were content to blame the instruments; and accordingly Dr. Thomson, by the assistance of Alexander Allan, contrived a new one with no fewer than thirteen different poises to a range of 130 degrees, with a thermometer and a sliding rule attached, which sliding rule was intended to estimate worts "of particular strengths;" and they give it this laudable character, that "worts of different strengths do not all expand alike; on this account the sliding rule would give erroneous results when the strength of the worts is very different from that for which the rule was constructed." We are then referred to Thomson's tables for instruction, and are told that the last column in the table "is not much to be depended upon;" for "the

worts, when so *very* strong, are so *very* viscid, that the instrument does not move with sufficient ease to give good results." Neither are any of his *other* columns to be depended upon, as shall presently be shewn; but such are some of the deserts of a saccharometer which was "appointed to be used by the Scotch Excise as far back as 1805;" and it is accounted a merit that "it indicates the specific gravity of the cubic foot of all liquids heavier than water, which is taken at 1000 ounces;" but this is no discovery, because all those that preceded it did the same; and moreover Dring and Fage had a sliding rule to theirs, and Baverstock hid his thermometer in his pocket from the prejudiced eye of his father, forty years before the Scotch commission was issued, and half a century before Allan's saccharometer had become so popular in Scotland, through the Scotch brewers having cheated themselves by the use of it, that the Excise forced them to continue the imposition. The Scotch law of the 56th Geo. III. c. 156, s. 44, enacted, in 1816, that "the instrument to be used in order to ascertain the gravity of wort or wash, shall be the instrument commonly called Allan's saccharometer; and all wort and wash shall, for the purposes of this act, be deemed, taken, and declared to be of the gravity at which the said saccharometer shall denote or indicate such wort or wash to be;" and the 4th Geo. IV. c. 94, s. 56, (1824,) declares that "for and in respect of every 100 gallons which shall be brewed and made in any distillery, of any distiller licensed under this act, the officer of excise shall charge such distiller with duty for a quantity of spirits at the rate of one gallon of proof spirits for every *five degrees* of gravity of such wort or wash as shall be attenuated; that is to say, for every five degrees of difference between the original gravity of such wort or wash, as declared by such distiller." Now, the main

object in saccharometry is to shew a true indication of the extract produced *per cent.* or otherwise; for the gravity of a wort ought assuredly to be a sign of its strength, and in the bright worts produced by attemperation it is precisely so; and as the distiller pays duty according to spirituous produce, which is dependent on strength, who knows whether a similar tax may not at some day be put upon beer? At all events, strength is a criterion of charge to the consumer; and where Allan exhibits 131·686 lbs. to the imperial barrel at an indication of 100, Dring and Fage give no more than $118\frac{1}{3}$ lbs.; and with a gravity of 150, where the former has 199 lbs., the latter only account for $170\frac{2}{3}$ lbs. One of them is therefore in error; and if the Scotch saccharometer indicates from 11 to 13 *per cent.* more than it ought to do, the subject requires vigilant care and correction.

The Scotch brewers, from want of proper attemperation and efficient sparging, appear, till the remarkable epoch of this celebrated commission, not to have produced so much good from their mashes as might have been wished; but from that period their extracts have been wonderful. Booth, the "practical man, being a brewer of twenty years' standing," and of course the cleverest practitioner whom the society could select, gives the following results from three quarters of malt, and his annotator considers this, as an experiment, one of his best:—

7·6 barrels of ale wort, of 30 lbs. gravity. . .	228·
5· barrels of return wort, of 2·5 lbs. do. . .	12·5
Imbibed by $13\frac{1}{2}$ lbs. of hops used	6·
Producing a total of	246·5

or $82\frac{1}{6}$ lbs. *per* quarter, being only $80\frac{1}{6}$, besides the

quantity absorbed by the hops; whereas the "Scottish ale-brewer," who gives two specimens of his own skill, obtains 111 lbs. *per* quarter in one instance, and 106·3 in the other, by the use of Allan's prolific saccharometer. This is a tremendous quantity, and requires that the intrinsicality of such an instrument should be tested warily and to the utmost.

Booth obtained his barrel factor by weighing his grains when he had evaporated them to the dryness of malt, and found them to be 308 lbs., leaving 617½ lbs. for the weight then missing, inclusive of the 246½ lbs. contained in his wort; and by dividing his whole extract by this his whole gravity, he obtained 2·505 as the "proportion of dry malt required to form a pound of specific gravity;" and the average yield by the old process, as taken from the twelve examples published in Dring and Fage's prospectus, is 2·495; and hence the observation that 2½ is very near the truth. Were malt all of a quality, these results would furnish the useful proposition that the barrel factor to each degree of gravity above par, is equal to the quantity of malt that yields a pound of extract; and at all events it serves as a line of guidance. With respect to the factor, Dring and Fage's principle, as already stated, is 2·77 (repetend) *per cent.*, or 277 to the gallon of 10 lbs., which is higher than agrees with other calculators; but Allan appears to have a constant factor, or rather one that varies and ought to be constant, of ·02967 or thereabouts, as he estimates the saccharine matter *per cent.* at 0·296 at an indication of 1 in gravity above par; 2·967 at 10; and 29·669 at 100. These figures, though too high, are strictly serial, and some of them stand confirmed upon their basis in his third table, where he has 0·0296 *per* gallon at the index 1, and 0·2997 at 10; but at 100 he has wandered wide from his principle, writing 3·2636, which is con-

siderably above the 10 lbs. *per* gallon deduced from his former computation; and the divergency will appear the more glaring when multiplied by 36 to express the quantity in each barrel, as he obtains 117·5 lbs. by the latter table, but only 106·8 by the former. We will now examine his indications at 15 and 150, to which he gives us 4·450 and 44·504 by his former table; but when we refer to his latter, or gallon of 10 lbs., his produce is 0·4517 at the lower standard, and 5·1182 at the higher; yielding 16·26 lbs. *per* barrel when the gravity is 15, and 184·254 lbs. when 150, which is an excess of 22 lbs. beyond the tenfold product, which is inconsistent. Surely, where a community is imposed upon by legislative enactments founded on false theory, and extorting from them more than the truth would require, the exposure of the egregiousness of a fallacy so extensive and hurtful, is an act of common friendship to all.

Evil generally spreads and is fostered, while good sleeps unheeded: thus, the English Excise, infatuated and misled by the success of the plundering project in Scotland, caused by monopoly and exclusiveness, issued an order through the Lords of the Treasury, dated 17th October, 1823, commanding that "for the information of all persons using hydrometers and saccharometers, none but those made by Mr. R. B. Bate, of the Poultry, London, will *support them in any suit at law* in any matter of dispute relative to the strength of spirits, &c. They are the only ones recognized by law, and used by officers of excise." Let us see, then, the extent to which the English Excise has applied its wisdom in this restriction:—In the fourth table to "Bate's Patent Saccharometer," published in 1837 with his "Directions," we are told that "the proportion of solid extract by weight" is ·0026 upon 1 degree of gravity, ·0255 upon 10°, and ·2357 upon 100°; but intermediately ·0381 upon 15°,

and ·3394 upon 150°; all of which denote, that if any standard factor have really been assumed, it has not been wrought into a regular expression, though he was bringing out a saccharometer, if we believe him, "at once *convenient* and *truly accurate*, where nothing was taken for granted or guessed at," (except, perhaps, the regular necessary graduating factor or additor,) "but, on the contrary, great diligence and scrupulous exactness were employed, and neither expense nor labour spared," though the factor lies *somewhere about* ·026 after all. Referring to the table above noticed, the extract in the gallon of 10° gravity is stated at ·258, but for a gravity of 100°, it is put down at 2·593, which certainly differs far enough from 10 times the ·2657 placed by its side in the adjoining column, the extract being a great diminution; whereas Allan, as has been shewn, makes it a large increase.

The fact is, as the tables clearly prove, that instead of seeing that the gallon ought everywhere to be exactly 10 times the gravity of the "proportion of solid extract" there named, and in some places is really so, there is a very general want of correspondence, for which no arithmetical reason can be assigned; for he begins by making the gallon less than 10 times the factor for extract, and ends by valuing it at 11½ times as much, the gallon being represented at 3·903, and the extract at ·3394, when the gravity is 150°; whereas Allan, by a perpetual augmentation in his scale, peculiar to himself, gives an overweight of ·6227 of a pound, or about 10 ounces to every gallon, more than his own original factor would produce at 150 times its inordinate capacity. It is useless here to argue supinely that *comparative* indication is enough for any man's purpose; for here is no comparative steadiness; and if there were, no man could estimate his income, according to his strength, by any

such vague comparisons; for no one can be correct who employs a false saccharometer, and especially if he relies on such tables as those of Allan or Bate, which, being under the wing of the British Government, ought to exhibit unequivocal accuracy; but as this is not the case, the license of toleration to either of them, let alone the compulsion to use them, is unpardonable. To place the matter in a clearer light, the plain quantities of solid extract *per* barrel and *per* odd gallon, as enforced by the Scotch and English excise laws, stand thus:—

Specific Gravity by the Saccharometer.	Quantity of Solid Extract in Pounds.				Excisable difference in each Barrel.
	In each Gallon.		In each Barrel.		
	Allan.	Bate.	Allan.	Bate.	
1001	0·0296	0·026	1·0656	0·936	0·119
1010	0·2997	0·258	10·7890	9·288	1·501
1015	0·4517	0·387	16·26	13·932	2·328
1100	3·2638	2·593	117·484	93·448	24·036
1150	5·1182	3·903	184·254	140·508	43·746

Taking, therefore, the results at large, from these two legalised national monopolists, without any present notice of temperature, which in many places would enlarge the disparity, the above specimens from a whole range of similar discrepancies, distinctly prove that whatever test be applied to the Scotch saccharometer, it everywhere indicates considerably more than it ought to do; and of this, all brewers who have used any other are aware, let the Scotch distillers murmur or not.

Bate's improvement upon his predecessors appears to consist chiefly in having five poises instead of Allan's thirteen, and a float to shew which of them will act applicably in each case, and in the abolition of the sliding rule, for which he substitutes a volume of tables

for practical men; and he tells us, in the description of his instrument, that "great care has been taken to preserve, by its figure, the utmost sensibility of motion and freedom from the liability of retaining air;" and the compiler of his "Directions" assures us that the experiments on density, taken to investigate the power or law of expansion, were 346, and the actual weighings in experimenting on extract, 290. His tables are exceedingly voluminous, and elegantly displayed, the third alone containing 40,000 figures, in more than 10,000 numbers, and covering a range of 448 columns, occupying 16 pages, calculated to every degree of specific gravity from 995 to 1150, and to every alternate degree of temperature from 50° to 150°; but after all these precautious arrangements, it is scarcely possible to look down a double column of degrees and results, and especially towards the right, and there to discover such regularity in the deductions, as we had learnt to infer and expect; or yet to find that the numerous assistants came to any new practical conclusion, but have merely followed in the general track marked out by saccharometrians long before any interposition of theirs. They certainly have laboured long in the composition of their "Ready Reckoner," in order to supersede the slide; but by applying a proper theorem, such tables may be checked, or entirely dispensed with.

Now, as the saccharometer or "brewer's compass" is not a simple tool like a yard wand or quart pot, but a compound machine indicative of weight and measure combined, and affected by every delicate measure of heat and humidity, its correctness is of the utmost consequence to those who would prefer facts to lame comparisons; and the simpler the corrective, the better understood and more extensively available. The author is indebted to a somewhat obscure but ingenious pro-

vincial work for his first introduction to Mr. Long, of Tooley-street, Southwark, whose saccharometer deserves to be particularly noticed on account of its elegance, and the simplicity of its principles. It has only one poise, and that only for wort exceeding 25 lbs. gravity, or 65 lbs. of extract *per* barrel, and was, in 1835, the only instrument that shewed the strength of worts by the imperial barrel.

Mr. Long says in his synopsis, that a 20 lbs. wort *per* barrel gravity contains 52 lbs. of extract, or solid fermentable matter, and consequently that each pound of gravity that the barrel exceeds water, contains 2·6 lbs. of saccharine or other solid extract, which at ·06154 parts of a gallon for each pound, occupies the space of 3·2 gallons of the liquid, leaving 32·8 gallons of the water, which at 10 lbs. to the gallon amount to 328 lbs.; to which, when the 52 lbs. of extract are added, the total weight of the barrel is 380 lbs. as it ought to be; thus clearly demonstrating that each degree of gravity in lbs. *per* barrel above par, contains 2·6 lbs. of saccharine or solid matter, and that each pound really occupies ·06154 parts of a gallon, and displaces that quantity of water in each gallon that contains it. On what authority this ingenious mechanist has founded his barrel and extract factors, he does not say; but it is evident that if a gallon of solidified sugar weighs 16¼ lbs., which shall forthwith be shewn (see page 231), the factor ·0615384 will correspond, and we take the admission as granted; and as Booth used 16·65 lbs. for the weight of an old ale gallon, or 16·3 imperial, and this is allowed by the Scotch calculators, in one place, "*rather* to exceed that of pure sugar as determined by Fahrenheit," and in another "to weigh *about* 16 pounds," Long's principle appears correctly based; or at least he has as good a foundation for his factor as any of his predeces-

sors; and he informs us, moreover, that he was advised by a gentleman of known experience as a London brewer, to make gravity the principal feature of his instrument, with a line of comparisons of extract *per* barrel; and on the reverse side he has a "line of barrels with an appropriate line of gravities, by which the brewer is enabled to regulate his lengths," and to produce uniformity of strength from a superior or inferior malt." He has also a line of shillings "for estimating the value of malt according to the strength produced, whereby the brewer is enabled to calculate the worth of malt as well by sample as brewing," and to save the trouble of a reference to common alligation; and he gives a number of examples of his mode of applying his thermometer and saccharometer side by side, by which correct results in the reduction of heat "are at once given, without calling in the aid of the sliding rule in the common routine of business."

These principles demonstrate the solidity of their basis, and the commercial usefulness of the instrument; and though Mr. Long cannot bask in the influence of auspices such as an impartial government has at command, and is therefore unprotected, he has at least the consolation that no legal *veto* is put upon the production of his ingenuity.

Having traced the history and progress of saccharometry from its birth to its present mature state, the author presumes to advance his own sentiments on the subject, from which it will be seen that his deductions differ but slightly from those of Messrs. Bate and Long. Since 1728 inches are a solid foot, containing 1000 ounces of water or 1625 of saccharum, the weight of an inch of the latter is ·9404 of an ounce, very nearly; and, adopting the arithmetical rule of Alligation Alternate, founded on the practice of the schools, and taken by them from Archimedes' solution of Hiero's adulter-

ated crown, which unites quantities with reciprocal differences, as in the experiments, chap. V., p. 161, taking any determined indication of specific gravity, as 1001 for example, the quantity of extract and of water respectively contained in a compound of the saccharometric gravity 1, is thus found: Differences between mean and extremes 624 and 1; products $624 \times 1000 = 624{,}000$; and $1 \times 1625 = 1625$; sum of products 625,625; which divided by 625, the difference in ounces between the compounded quantities, gives 1001, the *status*, as it ought to do. Then, to constitute a solid foot, or to obtain a general factor, we have 625 : 1728 :: 624 : 1725·2352 :: 1 : 2·7648; and taking these results and exhibiting them in plain figures, to show that they are the *real* equivalents of a solid foot, we have, by the same process,

$$\begin{array}{ll} 1725{\cdot}2352 \times 1000 = & 1725235{\cdot}2 \\ \underline{\quad 2{\cdot}7648 \times 1625 =} & \underline{\quad 4492{\cdot}8} \\ 1728) & 1729728(1001. \end{array}$$

Proof, as before.

Therefore the weight corresponding to this indicated degree of extract is $2{\cdot}7648 \times {\cdot}9404 = 2{\cdot}618$ ounces in addition to the water, or ·02618 lbs. to each imperial gallon of 10 lbs.

Though scarcely needful to pursue the subject farther, it shall be advanced one more stage, to show that the factor 2·7648 is constant; and, therefore, those computers who alter their factor as they proceed, or who are liable to waver in their estimates, are visibly in error. As 1000 : 2·7648 :: 1625 : 4·4928, which furnishes an easy mode of estimating for any other indication, as for instance 1002:

$623 \times 2764{\cdot}8 = 1722470{\cdot}4$ and $2 \times 4492{\cdot}8 = 8985{\cdot}6$; sum 1731456, the 1728th part of which is 1002, as required, and at any other point of gravity the corresponding result would transpire, which establishes the constancy and validates the theorem, either by testing

every point thus, or by adding the factor 625 times or multiplying it by 625; the solution in each case is 1728, and shows that if the system could be carried out till liquidity ceased, the mass would be solid extract of the true specific gravity 1625.

Dr. Thomson fixes the specific gravity of saccharine matter at 1552, and others at different standards, but this appears to be rather dilute, and nearly agrees with the sugar of milk, which is 3½ *per cent.* lighter than solid cane sugar, which accordingly is about 1606; and sugar of malt is heavier than either, but undoubtedly varies a little according to quality. As the doctor has not cited the authority on which he has built any formula for his assertion, we may compare it with the equalisation of Quin, Richardson, and Dring, as given in the "Hydrometrical Observations," where 2·6 lbs. of solid extract are considered equivalent to each point of gravity indicated above the water standard of 1000, a pound occupying ·06 of an old ale gallon, or 16·92 inches; and 16·92 in. : 16 oz. :: 1728 in. : 1634 oz., which will give 1606 for imperial measure; but the common factor 2·6 has been found too small, since on dividing 1728 by it, we obtain 664·6 old, or 653 imperial, which is more than can be justified. Dicas had a factor of 2⅝, which Dring and Fage altered to 2⅞, as adapted to the imperial standard, which has been much tested, and gives the specific gravity of solid dry extract 622 above water.

Again, if the elements of cane sugar, given at p. 33 above, be multiplied by their respective atomic weights, C. ·75, O. 1·0, H. ·125, the aggregate will be 83·345; and that of the sugar of malt 84·746; and on applying the same test to mucilage, p. 43, the aggregate is 84·829, differing from the sugar of malt only by 1 in 1021, and fixing the resulting specific gravity of malt sugar thus: 83·345 : 1606 :: 84·746 : 1633, agreeing very nearly

with the result as computed by Long's saccharometer. But starch is lighter than either, its aggregate being 83·825, which is 1 in 92 under the saccharine, and 1 in 83½ under the mucilaginous solution; and hence the worts are at the heaviest before they attain the desired clearness; but so near are these conditions, that the ponderable difference cannot be correctly perceived by means of the instrument. This is why Baverstock, and the controversialists in "Cobbett's Register" for 1808, would not trust the saccharometer to place a transparent wort above a thick or cloggy one of the same materials and length, and why the attemperated worts produced by the patent machinery do not appear to due advantage when tested by it; but this does not alter their intrinsic value, or yet the scale of their comparative density one with another.

The subjoined table exhibits the variety of opinions which dealers in saccharometers have expressed, and shows, at least, that some of them cannot be relied on. To these the compiler adds his own results, as deduced from the process he has explained, and he shall be happy to find that the issue of his enquiries has led the public brewer, more effectually than heretofore, to guard his own interest by stricter attention to the quality of his worts. The numbers by Allan, Bate, and Long, are extracted from their printed tables, the others from their simple factors, and the visible diversity, though entertaining as a curiosity, shows lamentable instability and inaccuracy in business.

Specific Gravity.	Weight of Solid Extract to the Imperial Gallon.						
	Dicas.	Richardson.	Dring and Page.	Allan.	Bate.	Long.	Tizard.
1010	0·266	0·2535	0·2777	0·2997	0·258	0·2583	0·2618
1020	0·533	0·5070	0·5555	0·6053	0·516	0·5194	0·5236
1030	0·800	0·7606	0·8333	0·9168	0·775	0·7777	0·7854
1040	1·066	1·0141	1·1111	1·2343	1·033	1·0388	1·0472
1050	1·333	1·2676	1·3888	1·5577	1·293	1·3000	1·3090
1060	1·600	1·5211	1·6666	1·8870	1·552	1·5583	1·5708
1070	1·866	1·7746	1·9444	2·2223	1·812	1·8194	1·8326
1080	2·133	2·0282	2·2222	2·5634	2·071	2·0777	2·0944
1090	2·400	2·2817	2·5000	2·9105	2·332	2·3388	2·3562
1100	2·666	2·5352	2·7777	3·2636	2·593	2·6000	2·6180
1110	2·933	2·7887	3·0555	3·6226	2·854	2·8583	2·8798
1120	3·200	3·0422	3·3333	3·9875	3·116	3·1194	3·1416
1130	3·466	3·2958	3·6111	4·3584	3·378	3·3777	3·4034
1140	3·733	3·5493	3·8888	4·7352	3·640	3·6388	3·6652
1150	4·000	3·8028	4·1666	5·1182	3·903	3·9000	3·9270

After a deliberate perusal of this table, the brewer will do well to pause ere he determine whose saccharometer he will use. Dicas and Richardson are now out of date; Allan out of the question, except as regards extravagant charges; Dring and Fage rather too high when compared with the truth set forth in the last column; and Bate and Long a trifle below it, differing only in the simplicity or complication of their respective instruments, and the regularity or irregularity in the gradation of their numbers: such, however, is simple saccharometry. We will now consider it in its compound state, as connected with temperature and dependent upon

The Doctrine of Expansions.

This is the system of reducing hot worts of any temperature and gravity to the quantity they will gauge when cold, or when lowered down to the standard of 60°. On an examination of Allan's theory, as published in his table, No. 1, we shall find that by reducing from 150° to 60°, the addition to be made to the apparent

gravity, if taken at the highest point in the scale, is 14·7, at 100 only 14·5, and at all the intermediate stages 14·9, which is anomalous, while at any mark below 15 gravity no notice is taken by him; though fluids take a wider range of heat at low gravities than at higher to effect an equal change, an increase of temperature from 60° to 125° at the *zero* or par of 1000, giving the same expansion of 10 points gravity, as a rise from 60° to 110·8° at an indication of 150 points higher, which only shews that water is more elastic than the saccharine extract embodied within its volume; but on a more thorough inspection of the aforesaid table, the "increase of quantity to be added," which is about 1 *per cent.* to every 5° at the high gravity of 150, is 1·2 at the lower of 100, according to such absurd calculations as his sliding rule affords; truly, therefore, as he says, his works are "not *much* to be depended upon." But the reductions from apparent to true gravity, according to Dring and Fage, are regular and systematic, requiring more expansion at high heats, where the heat increases the elasticity, than at lower, where it has less force, presenting a series thus: 1·2 + 1·4 + 1·6 + 1·8, &c., upon each 10° above 60°. So do Bate's tables; so does Count Rumford; but Allan sometimes reverses the order as above, sometimes exceeds it, sometimes vacillates, and is sometimes gradual in his reduction for 30° or 40° together; thus, his allowances for reducing from 130° to 60° of heat run as follows for each 10°, beginning at the lowest:

At gravity 50, his numbers give 1·40 + 1·24 + 1·32 + 1·54 + 1·90 + 2·00 + 2·40, sum 11·8;

But at 80, his series adds to 1·60 + 1·60 + 1·80 + 2·00 + 2·00 + 2·00 + 2·20, sum 13·2;

But Bate's series is more regular, analysing into

Gravity 50, reduction 1·2 + 1·4 + 1·6 + 1·8 + 2·1 + 2·3 + 2·5, sum 12·9;

Gravity 80, reduction 1·3 + 1·5 + 1·7 + 1·9 + 2·2 + 2·4 + 2·6, sum 13·6.

Hence, though Allan, or rather Thomson, soars far above others in his original gravities, he creeps below them in his allowances for heat, as though the law of expansion in heating fluids were natural in one place and unnatural in another. According to Bate's experiments, the allowance for expansion throughout the brewer's range stands as follows, for each 10° of heat from 60° to 150°.

Sac. Grav.	Series, 9 terms, each 10°, from 60°.	Sum.
10	1·0+1·2+1·5+1·7+1·9+2·1+2·3+2·5+2·8	17·0
50	1·2+1·4+1·6+1·8+2·1+2·3+2·5+2·7+3·0	18·6
100	1·4+1·6+1·8+2·0+2·2+2·5+2·7+2·9+3·2	20·3
150	1·6+1·8+2·0+2·2+2·4+2·7+2·9+3·2+3·4	22 2

The following abstract, taken by glancing obliquely across the whole table of 40,000 figures and noting the equivalents, may be made to suit all the purposes of saccharometry. Where the correspondent degree of temperature does not occur in Bate's table, a correct proper fraction is here attached at an average. The principle it embraces tends to this, that when a liquid whose specific gravity is 1000 (first line) is expanded from 60° to 79° of heat, its gravity is reduced two points, when to 93° four points, &c., or the instrument would sink those points if removed from a wort at 60° into one heated to 79° or 93°; or (second line) when the index cuts at 10 at 78° or 92°, &c., it would give only 8 or 6, &c., if the heat were reduced to 60°, and that which indicates 10 at 124°, would float at *zero* at 60°; those differences, therefore, of 6, 8, 10, &c., must be respectively added to the apparent gravity at those heats, as equivalents for the rarefaction, to give the true gravity when cooled down to 60°.

Specific Gravity at 60°.	Other apparent Gravities, giving the same true gravity at the accompanying heats, as the first column at 60°.									
	Ap. gr.	Deg.	Ap. gr.	Deg.	Ap. gr	Deg.	Ap. gr.	Deg.	Ap. gr.	Deg.
1000	998	79	996	93	994	105	992	115½	990	125⅓
1010	1008	78	1006	92	1004	104	1002	114½	1000	124
1020	1018	78	1016	91⅓	1014	103	1012	113½	1010	122⅔
1030	1028	77⅓	1026	90⅔	1024	102½	1022	112½	1020	122
1040	1038	76⅔	1036	90	1034	101½	1032	111½	1030	120⅔
1050	1048	76	1046	89⅓	1044	100⅔	1042	111	1040	120
1060	1058	76	1056	88⅔	1054	100	1052	110	1050	118⅔
1070	1068	75⅓	1066	88	1064	99	1062	109	1060	118
1080	1078	74⅔	1076	87⅓	1074	98	1072	108	1070	116⅔
1090	1088	74⅓	1086	86⅔	1084	97½	1082	107	1080	116
1100	1098	74	1096	86	1094	96½	1092	106½	1090	114⅔
1110	1108	74	1106	85½	1104	96	1102	105½	1100	114
1120	1118	73½	1116	85	1114	95½	1112	104½	1110	113⅓
1130	1128	73⅓	1126	84½	1124	94½	1122	104	1120	112⅔
1140	1138	73	1136	84	1134	94	1132	103⅓	1130	111⅔
1150	1148	72⅔	1146	83½	1144	93½	1142	102⅔	1140	110⅔

Some brewers, and indeed many, though this subject materially affects their interest, have never given it a serious thought, perhaps because they considered it intricate; but it is not so; and it may be as well for the practical man to carry his scale of reductions in his own head, as to fly on each separate occasion of pondering his worts, to fallacious sliding rules or false tables. The expansion of water in heating, or its contraction in cooling, as ascertained by Count Rumford at every 22½ degrees in its progress from the boiling to the freezing point, or from 212° to 32°, is as follows:

From 212° to 189½° are 18 parts.
—— 189½° — 167° — 16·2 —
—— 167° — 144½° — 13·8 —
—— 144½° — 122° — 11·5 —
From 122° to 99½° are 9·3 parts.
—— 99½° — 77° — 7·1 —
—— 77° — 54½° — 3·9 —
—— 54½° — 32° — 0·2 —

Being 80 parts in all, of which 34 lie between the limits of 150° and 60°, at an average variation of $\frac{1}{10}$th to each degree of expansion; so that one of his "parts" is just equal to 2° in the reduction of gravity, as set forth by Bate or Dring and Fage; and the whole, for each 7½° from 54½° upwards, analyses into the series

1·0 + 1·3 + 1·6 = 3·9 ; 2·0 + 2·4 + 2·7 = 7·1 ; 2·9 + 3·1 + 3·3 = 9·3 ; 3·5 + 3·8 + 4·2 = 11·5 ; 4·4 + 4·6 + 4·8 = 13·8 ; 5·1 + 5·4 + 5·7 = 16·2 ; and 5·9 + 6·0 + 6·1 = 18 ; which results differ but little from the experience of the English excise. Here, then, is a theory laid down on which the operator may depend without the rule or the tables, and which he may reduce to practice thus :

Theorem for reducing the gravities of hot worts.

To unity or 1, representing the par or standard of water, add ·1 (or $\frac{1}{10}$th) for every 25 points of gravity indicated by the instrument, and ·01 (or $\frac{1}{100}$th) for each degree of temperature above 60°, and multiply the sum by 10 times the latter number, for the correction. Add this to the apparent gravity, omitting decimals, and the result will be the true gravity.

Example 1. Apparent gravity 6, temperature 92°. Here $(1 + \cdot32) \times 3\cdot2 = 4\cdot224$; and $6 + 4 = 10$, the true gravity as given in Bate's elaborate table.

Ex. 2. App. grav. 27, temp. 124°. This is $(1\cdot1 + \cdot64) \times 6\cdot4 = 1\cdot74 \times 6\cdot4 = 11\cdot136$; and $27 + 11 = 38$. Bate gives the true gravity 37·6.

Ex. 3. App. grav. 100, temp. 110° ; give $(1\cdot4 + \cdot5) \times 5 = 1\cdot9 \times 5 = 9\cdot5$; and $100 + 9 = 109$. True gravity again, exactly as in the table.

Now, whatever gentlemen may surmise, the author takes to himself some small degree of credit for the discovery of this little theorem, in which the whole business of reducing hot worts consists ; and he is fully persuaded, that by practising it with Long's saccharometer and an attached thermometer, all may be accomplished in *one minute* which has often occupied *an hour* in referring and computing, besides giving incorrect results.

CHAPTER VIII.

HOPS.

USE, INTRODUCTION, AND HISTORY—PROGRESS AND CULTIVATION—DRY AND SWEET WINES—TEA—OLD AND NEW OPINIONS—BAVARIAN LADIES—HOP GROUNDS—LUPULINE—CONDITION—TESTS—CAUSES—FRAUDS—NECTARIUM—THE GOOD ARTICLE—SEEDS—BAGS AND BAGGING—THE HOP CONVERTOR—STEAM PIPES AND HEATED FURNACES—PRESSURE AND REGULATION OF STEAM—MISREPRESENTATIONS BY COPPERSMITHS—HUMULINE PATENT—ABSTRACT OF DUTIES.

THE brewer having made the most and best of the malt and water committed to his care, by converting it into wort, now unpalatably sweet and viscous, whether obtained by the patent machinery or otherwise, his next object is to bring this wort into a potable state, and to ensure the permanence of its virtue: this is done by converting a portion of it into alcohol, which important change is effected by means of fermentation; preparatory to which, an impregnation with some additional substance calculated to produce the desired flavour and durability, has ever been found necessary; and various, according to the circumstances of taste, custom, and restriction, have been the substances used and the mode of using them.

Liebig observes in the second edition of his Chemistry, page 320, that most of the blossoms and vegetable substances that yield a scent, owe it to a volatile oil that exists in them; but that others do not emit odour except when they undergo decomposition or change; and he notices that different kinds of tobacco,

like different wines, are distinguished from each other by having different odoriferous substances generated together with their nicotine. He thinks it also probable that the odorous principle peculiar to each of various vegetable substances is newly formed during the fermentation of the saccharine juices of the plants. Very small quantities of elder, violet, cowslip, or linden blossoms, added to a fermenting liquid, are sufficient to impart a much stronger taste and smell than could be derived from the water distilled from a hundred times those quantities. Thus the various kinds of Bavarian beer are distinguished by different flavours given them by fermenting small quantities of the herbs and blossoms of plants with the worts; and *sage* and *rue* of various species are added as a *bouquet* for fraudulent purposes, to wines fermented on the borders of the Rhine; though he says that "the fictitious perfume thus obtained differs from the genuine aroma by its inferior durability, and by being gradually dissipated."

But it is not so much for the sake of introducing a bitter that shall neutralise the disagreeable sweet of malt wort, as for the intention to add a stimulus and attendant flavour, as imparted by these *bouquets* of flowers, that the blossom of the hop has become the *nosegay* of the British brewery. For information on the use of this aromatic acquisition, the author may next refer to Dr. Ure, who attributes its peculiar virtues to a yellow pulverulent substance which, when distilled in water, affords about 2 *per cent.* of a colourless volatile oil, the basis of its flavour, to which the much admired aroma of the plant is justly attributed; that it dissolves in water very readily, and that it contains sulphur, because it blackens solutions of silver and acetate of ammonia. With respect to this *boiling*, however, we do not see that in the Bavarian and Rhenish provinces it is

adopted as a means of preserving the aroma; though the expedient may have been introduced in England instead of a better, and habit has confirmed the practice. Without attempting to dispute with profound chemists and experienced brewers, the author must say at the outset, that he altogether disagrees with the plan, and that as soon as the principles of this staple article, and of the dealers in it, have been duly examined, he shall again embody his reasons for this difference, and set them forth more fully than before; and he cannot yet do otherwise than entertain the idea that some of the sulphur noticed by the Doctor is drawn from the drying fuel, or from the sulphurous *bleaching* matter that many growers illegally employ in "getting up" their hops: a crime practised by a similar class of sinners in the manufacture of malt also.

This excellent plant, the hop, as well as sugar, has long been justly appreciated, and is well adapted in its admirable nature to suit the service of man; for it appears to have been cultivated from time immemorial, though it has not had its physician to commend its virtues quite so strongly as the latter; nevertheless, we have an old authority in Pliny, who describes it as a plant reared in Germany in his day, as a *pickle* or *preservative relish* to beer, and as entwining itself round *other willows* with which the *Netherlands* then abounded; and his words in one instance are very plain: "*Lupo salictario Germani suam condiunt cerevisiam.*" Another remarkable fact is, that the word *lupus* did not only signify a *hop*, but any thing *bitter*, or having *more bite* than another, as a wolf, a pike, a spider, a hook, a *bit* or snaffle, and the like; whence also, by an idiomatic contraction which marked the language of barbarous Europe in those days, come *lop*, to cut short or bite off, and by corruption *hop;* or the Romans may have borrowed the

latter term from the Germans and harmonised it to their own language, and introduced *lupulus*, a diminutive of *lupus*, because they found the hop to be *a little bitter*. We may very reasonably suppose that British malt or barley wines were drunk in an unboiled state prior to the introduction of that ingredient as a general bitter, just as home-made wines are now, and that boiling was deemed the readiest way of employing it in large quantities, as would undoubtedly have been likewise the case if the public taste or the perishable quality of the grape wines had been such as to demand the addition of the essential oil, &c., of other plants, such as hops, for instance; but grape wines are not boiled in the ordinary treatment, and yet their attenuation is perfect, and many of them are not prone to acidity.

Of course, dry wines are here alluded to, and those generally used in this country; though we know that some of the French domestic sorts are highly concentrated and luscious, resembling syrups, a state to which boiling with brandy and aromatic seeds is necessary. In Italy and Spain, also, to hear of wines being boiled to concentrate the sweet principle, and to retard the formation of alcohol, is not an uncommon thing. Boiled wines are of great specific gravity and dark colour, and are designed for admixture with the produce of bad vintages and a certain quantity of alcohol and other surreptitious qualification. Sherry, Malaga, Tinto, Sherbet, Cyprus, and many others, are either sophisticated or are imitated by the aid of the syrup wines, from which they derive foreign colour, alien aroma, borrowed sweetness, and stolen spirit. Wines are never boiled to improve their *bouquet*, or to render them superior to the natural productions of such fruit as contains the essentials in adequate proportions; but on

the contrary, instances are on record where the boiling principle has for its object the deterioration and transformation of the vinous property for some commercial fraud, or perhaps for an ecclesiastical deception. For instance, Marco Paulo found that the Mahomedans of Tauris, as much as 500 years ago, swindled their prophet by boiling the juice of the grape for the purpose of changing its character and name, and thus removed the impediments which their religious faith had placed between their enjoyment and their duty; like the old woman at Newcastle, who, being a teetotaller, dipped rolls in gin and ate them, to evade the penalties to be inflicted on her if she *drank* ardent spirits.

It was undoubtedly from this principle of drawing out virtue by heat that people first began to boil hops; and they did the same with the leaves of the *Thea* plant, now universally called *tea* by our countrywomen, when it was first imported into Europe in 1610, by the Dutch East India Company, and into this country in 1666, by Lords Arlington and Ossory, whose names are in other respects familiar to us. At first it was so highly esteemed that it sold as high as 66*s*. *per* lb.! but being easily *brewed*, it began to supplant the hop and hopped beverage at the tables of the great; and accordingly the first duty imposed upon the consumption of this commodity was 8*d*. *per* gallon on the infusion when sold in coffee-houses; but this mode of levying a duty was soon removed, the leaf became more common, and many ludicrous instances arose. One elderly lady, among others, had a nephew in the East India House, who sent her a pound of this precious exotic treasure as a present, with which she was so greatly delighted that she boiled the whole of it in a large pot or family copper, as the temperance societies of to-day are accustomed to do when they regale large assemblages of

proselytes at their speech-makings; and having done this, she invited her friends, consisting of relatives and neighbours, to partake of the delicious treat sent by Joseph: such is the laughable origin of tea parties in England; and why, we can ask, may it not be equally ridiculous to see an old woman of a brewer boiling hops, when she can, as the tea-makers do, extract their aroma by infusion in hot water? That this is the main purpose for which worts are boiled, was evident to a writing brewer of extensive experience in the last century, who justly remarked that the process of brewing for malt distillers was the same as for ale and beer, except that in the former the hops were omitted, and consequently the boiling also.

In the first chapter of this volume, the history of brewing is brought down below the time of introducing the hop, in 1524, from the Netherlands, to which country the plant appears to have been indigenous, as it was successfully cultivated there in the 14th century, and of course had grown there ever since the time noticed by Pliny, the Roman naturalist. The first licenses for the sale of *beer* in this country, making it a monopoly, were granted in 1552, the last year of Edward VI. In Elizabeth's reign, we are informed that the daughters of the nobility and gentry, after feeding their poultry, breakfasted at 7 on hot meat and ale, and dined at 11, except in cities, where the dinner hour was at noon; and the national beverage had then attained such celebrity, that brewings of it were appropriated, as fancy chose, to every little occasion, as *bride ale* to weddings, *leet ale* to court meetings, *lamb ale* to sheep shearings, and *clerk ale*, which was prepared by parish clerks, whose congregations furnished them with provisions during the week, feasted with them on Sundays, and bought the ale of them as compensation to

them in lieu of salary. Thomas Tusser, a celebrated agricultural poet of that age, wrote thus in praise of the hop:

> "The hop for his profit I thus do exalt,
> It strengtheneth drinke and it favoureth malt;
> And being well brewed, long kept it will last,
> And *drawing* abide, *if ye draw not too fast.*"

Thus far the progress of brewing till the hop had become a staple commodity; but a question may arise as to the article employed to bitter, to spice, or to preserve the ale before the value of the hop plant was discovered. Allusion has already been made to certain exciting drugs in which the people indulged when luxurious drinking was prohibited, and probably narcotics were likewise mingled with their drink. It is observed by Sir H. Davy, in his agricultural chemistry, that the diffusion of the bitter principle in the vegetable kingdom is very extensive, and that besides the *humulus lupulus* or hop, it is found abundantly in the *spartium scoparium* or common broom, the *anthemis nobilis* or chamomile, and in *quassia, amara,* and *excelsa;* from each of which substances it is extracted by the action of water or alcohol and evaporation, is usually of a pale yellow colour, is of great importance in the art of brewing, and is likewise taken as medicine, and is a check to fermentation and a preservator of fermented liquors, consisting, like the narcotic principle, chiefly of carbon, hydrogen, and oxygen, with a little *azote,* and may be extracted from hops by infusing them for some time in *cold* water. This certainly is the simplest process possible, and shows that the oil and bitter of plants may be drawn out by other means than boiling, which is expensive and dangerous. In some parts of Sweden, at this day, the *menyanthes trifoliata,* water trefoil, or buckbean, is dried and used as a substitute for hops;

and it undoubtedly makes an excellent English sudorific draught for the radical expulsion of rheumatic gout, when infused hot with ginger, horse-radish, and sassafras, to which it imparts an agreeable bitter and a deep colour; and there is no doubt, from the extreme bitter of the little pink centaury, noticed by Liebig as emitting an agreeable and penetrating odour when fermented, but that it is still used by some country people in the impregnation of their home-brewed harvest beer; and if the object be to make their bodies pliant by reducing their flesh, it will strictly answer their end. The use of broom is very common with poor people to whom the purchase of hops is an object, and so, in some villages, is that of wormwood, the *artemisia absinthium*, and of mugwort, the *artemisia vulgaris* of botanists; and a tradition prevails that this *genus* of plants, which is dedicated to Artemis or Diana, was medicinally employed to prevent the ravages of the plague during its malignance on the Welsh borders. At all events, the inhabitants of Coalbrookdale, where wormwood grows wild in abundance, well know its use as a bitterer and flavourer of ale, though the ale becomes disagreeable when it has been a few days on the tap. Hyssop, (*hyssopus officinalis*,) the Scripture purgative, and horehound, (*marrubium vulgare*,) are also found among the old catalogues of medicinal bitters used by our ancestors in the preparation of their daily beverage, and are commonly found growing in the gardens of old cottages and farm-houses, sometimes with a little superstitious reverence attached to their character, and are abundant in crofts and in the highway sides in some of our villages of ancient standing, as hops are in the hedges of gardens, orchards, stackyards, and the like. Of late years, quassia has been much recommended by druggists as an improving accompaniment to the hop; and more

recently still, chirayetta, a foreign herb much resembling centaury in its stalk, and said to contain as much warm and nutritive bitter in a scruple as hops in a pound, or 350 scruples; some people affirm, however, that chirayetta is not equal to quassia as an active preservative and wholesome stimulant to the alcohol of the wort, though chirayetta costs 3*s.* *per* pound, and quassia may be had at some warehouses for about 6*d.* With all these innovations, the British public need not be apprehensive that the hop will suddenly lose the good character which it has attained in this country, and has now preserved more than three centuries, unimpaired by substitution, adulteration, or prohibition.

Such was the demand for the hop when first brought into this country as an article of commerce, in 1524, as above named, or in 1530 as affirmed by others, and so great was the excitement caused in the minds of the authorities lest the consumers should shorten their days and ruin their posterity, that an Act of Parliament was shortly afterwards passed to prevent its further use; but the stricter the prohibition, the greater was the avidity to obtain it; and instead of its being put down, it became so common, and its culture had increased to such an extent, that in the year 1644, the 25th of Charles I., an excise of twopence *per* gallon was put upon beer, and the brewers were forbidden to use any other bitter or drug, or any ingredient whatever except hops, for the impregnation of their sale worts.

Malt, however, had been an excisable article from the year 1367, when a tax of fourpence *per* quarter was put upon it by the same policy which passed the restraint upon men's appetites, the said quarter of malt being then equal in value to an ox, and six oxen to a tun of good wine. The fact was, that the people found by experience that all other herbs and flowers were very

far inferior to the bloom of the hop, being generally coarse, rank, and less permanent. Indeed, no other substitute has yet been proposed at all likely to supersede the gratefulness of its fine aroma, to say nothing of the warm and cheering bitter peculiar to itself; though it cannot be denied that gentian, quassia, and perhaps chirayetta, may be advantageously used *with* the hops in times of scarcity and consequent dearth, such as the failure of a season or two might and would occasion; for at such times the price, or the supply at any price, precludes their exclusive use in the brewery throughout the year, particularly in the manufacture of "*India ale*" (for which see more at large in chapter XVIII.); and here gentian may be necessary.

In case of such a climax as this, though forbidden by strict law, men would be justified by reason and common sense in resorting to expedients such as satisfied their forefathers; and it would only be an act of gratitude to Providence to gather such shrubs and herbs for the use of man as are next best to the hop, being the most prolific of the essential oil and bitter. Under other circumstances, any deviation from the established alliance between malt and hops would be unjustifiable in a pecuniary as well as a moral sense; for brewers have been brought to know, that though "more powerful bitters than hops may perhaps be found," yet "the bitter can be of no use without the preservative property." Gentian and quassia, as observed many years since, "may be wholesome and useful when taken as medicines, but if introduced in beer, they would not fail to cause a rapid decrease in the sale," because they do not possess either the fine rich aroma or the preservative excellence peculiar to the hop; and the author will be candid enough to admit the old principle, founded on experience, without recourse to law, that "the entire

stock in trade of any druggist, although the value of it may amount to £20,000, is not worth the cost of a shilling to any brewer for the purpose of improving the flavour, or in any way contributing to the strength, of malt liquor, otherwise than as the articles may be *saccharine:*" an argument which the uninitiated will find more fully discussed in the 17th chapter of this treatise.

Lance has undertaken to tell us, on the authority of some chemist, that "a rich wort sheathes off the pores of the hop, and is unfit to extract the bitter;" which he wishes to confirm by comparison with green tea, a quarter of an ounce of which will not yield the same flavour with water sweetened with the same quantity of sugar that would be necessary to sweeten it afterwards, that it would if immersed in simple water. This may be true; but brewers usually work out their half-spent hops or their beer or return wort, in order to lessen the waste here anticipated; and this furnishes an additional argument why they ought not to be boiled. He also says, that the plant was known in England previously to 1524, and that in many places it grew wild by the sides of hedges, and its young shoots were often gathered by the poor, and eaten as an esculent vegetable; as they still are by many who are not precisely poor, and are preferred to asparagus. He likewise mentions the prohibition put upon them and sulphur by Henry VIII.; but he does not tell us, any more than his antetype Scot, whether in those days the worts were boiled, or whether they were infused separately, as we do tea and various herbs, and were added afterwards; but we may infer from above, that before the introduction of the hop as an improver of malt liquor, the beverage was generally termed *ale*, or at least the stronger portion of it, the hopped liquor being then designated *beere*, to distinguish it from the ale, in which herbs were decocted.

In old dictionaries we find new ale called *mustum*, which is a general term for a drink not brought to maturity; as Pliny calls honey that has not purified itself by working, "*mellis musteus fructus;*" and the term goes farther, as the same author has "*caseus musteus*," for fresh cheese, and "*liber musteus*," a new book; the word *must*, therefore, very properly applies to wort in the state of fermentation, or to any kind of liquor in an immature state. We also find, in the same fountains of information, "gill ale," described as "*cerevisia hederacea;*" but the *ivy* thus called *gill* is the *chamæcissus, hedera terrestris*, or *ground ivy:* a low creeping plant, called in Gloucestershire "*gill-go-by-the-hedge*," more viscous than hop, buckbean, or white briony, and found in vocabularies by the term *alehoof;* so that this seems to be the plant which distinguished ale from beer in the reign of Elizabeth, and with which is associated the word *gill*, a small measure of half a pint, or in London and some other places only a quarter; though it seems from the hoofs of the Saxon peg-tankards, that each man's gill in their day was a half pint. At one time it contained a sextary, or a twelfth part of a gallon, to which the Romans had an equivalent measure, by Plautus and Quintilian called a *hemina*, holding a twelfth of their *congius*, which rather exceeded our gallon.

In a few years after the introduction of the hop, people found out a method of keeping their beer longer; for in less than a century it had attained such celebrity in the upper classes of society, that even bishops, ever fond of good doings, as before shewn, were enamoured with its charms, like the Bavarian ladies of the present generation, who drink it regularly out of tall glasses, as French gentlemen do champagne; and so delicious is its flavour in that region, that the tables of the rich are

daily furnished with it in preference to wine; and surely it would be better both for the health and the purse, if the English gentry would renounce strong wines and ardent spirits, and follow their example. Indeed, Dr. Ure, never very ceremonious in compliment to the trade, goes so far as to say, that the *mystery* of brewing is more philosophically studied and *incomparably better understood* in Munich than in London, and throughout all Bavaria than in England, which he has ascertained "during several excursions into Germany."

Having said as much as necessary on the history of the hop, the nature and culture of the plant, and the treatment of its produce, require attention. Professor Liebig, who has deeply interested himself with the subject, has ascertained that hops contain much potash, soda, phosphoric and sulphuric acid, lime, and magnesia, though he does not find any such superabundance in the soil where they have grown; nor is it necessary, because their roots strike eight or ten feet deep into the soil, and search out the materials proper for nourishing the bines; and hence that they thrive well in land which in fit ingredients is comparatively poor, which is the case with all other plants whose roots thus extend themselves in search of food.

The variety of hops brought into the market is very great, and arises from many causes, of which the principal are soil, situation, culture, method of picking, drying, and general management; but the most precarious of all is the season. Each sort is distinguished by a name, such as the county or district in which it grew, and some are named after celebrated growers or dealers. Richardson found that the North Clays, so called from the stiff land in Nottinghamshire where they grow, were the rankest in taste, and fetched a better price with a certain class of buyers than those from Kent, though

not generally so high as the Farnham variety; but that to persons unaccustomed to North Clays, their rankness approaches to nauseousness, particularly while the beer is new, and remains for a considerable time, unless the accompanying extract from malt has great strength to cover it; and that therefore they appear to be fitter for strong beers brewed to keep long, than to any others.

Farnhams are in high repute, though not worth the price to the brewer that is usually given for them, unless the proximity of his residence be a consideration in their favour; and the county of Kent at large, though pre-eminent both for strength and flavour in a general way, differs in its produce according to soil and season, the one being sometimes suitable to the other, and sometimes quite the contrary. Those grown in the neighbourhood of Canterbury have been much prized for their superiority, but that is not invariable. The Wealds are celebrated in some of the southern and midland counties; but in the more northerly, as Cheshire, Lancashire, &c., Worcesters are preferred for their mildness, and for the grateful sensation which they yield to the palate; some use a few Sussex or Kents with them, but the generality of brewers in those counties reject the growth of Kent as unpleasing to their customers. Sussex is truly a hop county, and its produce is in great request in some districts, whereas in others they are guarded against with vigilant caution from having, according to the local taste of those parts, an intolerable smatch, which is a property distinct from the absolute bitter. Persons accustomed to the Worcesters, and accordingly to mild ale, usually designate such as is brewed with Kents by the term *porter ale;* but it must be remarked, that the stronger and purer the clear native bitter of the hop, the better will it withstand the casualties of site and season. Kent produces more than all

the rest of England, which proves them to be most in demand; and, as already observed, those from the east are often preferred for their more pleasant flavour; but the preference is far from uniform. For example, in 1844, those called Mid-Kents were considered the best grown, and consequently were worth the most money, notwithstanding how often the reverse happens. Nothing but a knowledge founded on direct observation each season, will enable a brewer to purchase profitably and judiciously.

As quality differs, so also does quantity, not only with regard to relative strength and relish, but also from variations of season; but to attempt to define the exact quantity for each distinct month of the year, or the quality best suited to any approaching season, would be ridiculous, even if the taste of the consumer had been previously ascertained by study; but generally speaking, the small delicate leaf of the Goldings, the Kents, and the Worcesters, has its share of admirers; but the more durable, either in malt liquors or out of them, are those that are full-grown, as ripe as possible, and with a strong thick leaf, which retains its virtues longer than a thin one. The portions called "choice," which are every year picked early while pleasant and young, and brought to market in an unripe state, to make a show and please the fastidious gentleman, are deficient both in flavour and in quality, which render them quite unfit for the purpose of any establishment conducted as a common sale brewery by an experienced man, though they may captivate butlers, and keep well enough in the cool vaults of an old English mansion. Hops do not possess all other good properties in proportion to their strength; and under this consideration the author engages the palest and mildest for light fresh ales, the strongest and most aromatic for the stronger pale taps, and the care-

fully picked Farnhams for exportation and for country imitation of the London ales; whilst those Kents of darker colour and more pungency or sting, which perhaps are likewise a little astringent, suit his idea the best when preparing for porter or long keeping. The brewers in the hop counties prefer the growth of their own locality, though not always with perfect wisdom; and many of the best of their samples are sent to the London market, where they are bought with avidity when in good condition, by the more liberal, enlightened, and scientific portion of the extensive merchants and brewers; for the Scotch and other country traders have of late either taught the Londoners by their example, or have stimulated them by competition, to the production of the very best and most splendid pale beers any where now to be found; though they cannot deny that the quality and flavour of London porter has of late years gradually fallen off, from a cause fully explained in our chapter on "*Porter.*"

Some brewers attend too much to the colour and too little to the odour of the hop, and thus expose themselves to the fraudulent practices of the growers, and thereby perpetuate the evil. According to Lance, whose "Hop Farmer" is one of the best written and most scientific books ever yet published in relation to the culture of this plant, and the management of its offspring, Lord Kenyon convicted a dealer, so far back as 1795, in a penalty of *five pounds*, for scenting or adding some species of drug to his hops, by which their natural colour and odour had been altered; and notwithstanding the liability that exists at the present time, as it did then, the growers in certain districts vie with each other in their several efforts to consume the largest quantity of brimstone with the greatest success in the drying

of their hops, that they may give them an artificial good colour, their own hue being too often in accordance with the nature of the fuel burnt, or the matter evaporated by it under the drying oast: thus a green tinge is imparted by burning charcoal, aided by the fumes of sulphur and saltpetre, partially coating the original brown of the blossom with a yellow, bright in proportion to the fraudulent skill and charge exerted to give to decayed age the hale bloom of youth, thereby seeking to provoke a repetition of that vengeance which induced the government under Henry VIII. to attempt at the abolition of the plant from within his territories:—enough, indeed, to startle the sensitive nerves of a political wiseacre, whose heroism led him to publish the following curious libel in the Mark Lane Express of the 4th of April, 1842:—

"*New Tariff.*—The hop-growers will not escape the New Tariff, although the import duty on foreign hops is not altered. Quassia, a well-known but *pernicious* substitute for the hop, now pays a duty of 8*l.* 17*s.* 6*d.* *per* cwt., which is to be reduced to 10*s.* *per* cwt. This heavy duty was intended to be prohibitory; the reduction of the duty will operate as a premium for using it, and the public may be *poisoned* at a cheaper rate." Silly mortal! Of all ignorant beings that breathe, the really ignorant cockney is the most ridiculously ignorant. Henry III. granted a charter to Newcastle for digging and coasting coals to London, but the sagacity of the natives "born within the ring of Bow bells," led them to petition Parliament in the following reign to remove them as a nuisance, and had their prayer granted; and a subsequent generation cried down hops as a poison! Brewers, be it known to such, can obey laws as well as other men, and can revere them as truly, and laugh at such

abject nonsense into the bargain; but they cannot laugh at a deceitful practice, which brings on them an odium that they have not earned.

Few hops, besides the best and most carefully picked Farnhams, come to market in their natural state of colour, and particularly of those sold to grocers for domestic consumption; and those that are accounted the best Farnhams are commonly picked too early for the mere prizability of colour; by which means the perfection and permanency of the natural fluid bitter are sacrificed to appearance and delicacy of the aroma. Good and uniformly ripe hops are generally injured by the gilding and bleaching extortion, particularly when they are designed for keeping, the sulphur being constantly disengaging itself, and extracting the oil and essence of the hop; and the fraud is further deepened by an enhancement of price in consequence of the green-yellow colour which it gives to the flowers; yet who can morally blame the grower for thus cajoling the brewer and conforming to his taste, when the latter insists upon it, and *pays him* for committing the deception?

No hop should be gathered till nature has matured the seed; for with it the juices and solids constituting its essential aromatic and bitter properties will also be ripe; and when in this perfected state, the nectarium or pollen will be in larger particles, and of a brighter yellow than is usually seen; the seed hard and brown, and the edges and tips of many of the blossoms tinged brown also; and then it is that when rubbed in the palm of the hand, they appear to dissolve into a resinous and oily, or rather a viscous matter, and emit a pungent and gratifying scent. An unbleached sample of this description is of real service to the brewer, and would be equally profitable to the grower if he would be

honest, because of the additional weight consequent to its fulness or maturity.

Besides the characteristics of hops already noticed, a plenitude of seed is a very good criterion of their quality, not for the sake of the seed itself, so much as for the quantity and quality of the farina consequent on the existence of the seed, which contains within itself a bitter pungent fluid; for it is well known that the interior of the seed is not available in the brewer's copper, the boiling being insufficient to break its hard though brittle shell; and this is proved by the extraordinary facts, that the seeds which have ripened within the influence of the male plant, will often vegetate after the severe treatment of boiling, and even after having passed through any animal that has fed upon them; evidently, it is advisable that the seed should be bruised if we wish to extract its virtue.

Botanists agree that nature has designed the nectarium and deposited it at the base of the petals of all flowers for the consumption and completion of their seeds; and here a question might arise, whether the reduction of the nectarium by the ripening seed, added to the cost of this weighty and at present useless matter, is compensated in any way, so as to induce the brewer to give preference to samples abundantly supplied with this first of criteria—seed. Upon reflection, comparison, and experience, the answer is at once affirmative, because—

Firstly, the supply of farina is healthy, and more abundant than the seed requires for its completion, and the farina of the male probably aids the perfecting process.

Secondly, the globules of lupuline of each blossom, when inoculated with the farina of the male plant and sufficiently ripe (for these are the principal necessary

conditions), are larger, and their contents are more pungent, oily, and resinous, all arising from their perfected nature.

Thirdly, a smaller quantity will suffice in the application, since it is richer in the bitter and aromatic principles, and the profit of the farmer is increased by the additional weight of such accompaniments.

It is also to be observed, that the growth of so many seeds in each blossom tends to expand the leaves and weaken their hold on the strig or strombile, in which state they are the more likely to break off the petals and become wasted in high winds, or during the process of picking, removing, drying, or bagging. To this remark only one objection appears applicable, which is, that the attentive and diligent grower will avoid such waste by every means within his reach; for as his interest is here at stake, he will gather his hops before they reach this extreme.

In order to mitigate the great loss usually attendant on the practice of keeping hops from one season to another, many futile schemes have been devised. Amongst the best, it has been proposed to prevent the formation of a "wind-cake," or dry brown exterior, and for their better preservation generally, to subject the pockets to a reduction of one-half, or at least one-third of their bulk, by means of the hydraulic press, or of levers and screws, and to smear them on the outside with some gelatinous substance, such as is used in the manufacture of oilcase or tarpaulin; or a cheap preparation of petroleum might be applied, which would amply repay those brewers who make it a practice, in certain states of the market, to purchase two or three years' consumption; and in general, when the price does not exceed £5 *per* cwt., the speculation answers well.

Lastly, of frauds. A greater imposition was never

practised by one class of men upon another, nor more passively submitted to by the dupes, than that of packing hops in heavy bags, weighing from 20 to 30 lbs. each. They cost the grower considerably less than pockets, and would not on the average, even when weighing 35 lbs., as many of them do, cost him more than three shillings, and these he sells to his customers for one, two, or even three shillings *per* pound; for whether the hops be sold in a bag, or in a pocket weighing only 4 or 5 lbs., that bag or pocket is invariably weighed with the contents. Certainly between the two there is some difference of price *per* cwt., but this difference is not commensurate with the weighty bag, about one-fourth of which only is deducted as tare. Before the introduction of the rude bag, there was but little cause to complain of this singular mode of charging for the wrapper; but now, in some cases, the brewer is actually obliged to pay as much as 40*s.* or even 60*s.* for nothing. Why do not the brewers insist upon dealing with the hop-grower or the factor upon the same system as with other traders, by deducting the full weight of the bag as tare, and paying a fair price for each bag or pocket, be it coarse or fine? If the security of the hop from the deteriorating effects of atmosphere and time were equal to the charge thus made for the bag, the imposition would be somewhat alleviated by long keeping; but it is the reverse; and moreover, bags are inferior to pockets in the nature of the barbarous material of which they are made, and the loose manner in which they are fabricated, all too evident from their crackling sinews and gaping ribs upon that greater tightening which should never be omitted at least twice a year, at the times of the spring and fall of vegetation. So far hops: now for the using of them.

It is a general practice with chemists, and perhaps

the only process to which they have recourse when an essence is to be obtained, such as that of roses or violets or the like, to *distil* the article in alcohol; and that which evaporates and is again condensed, is the desired aromatic liquid. Now brewers distil their malt and hops in a similar manner, but do not take the precaution to preserve their volatile oils, &c., by means of a condenser, and the extract suffers in consequence. This waste was made evident a few years ago, and the dome copper was introduced for its preservation; but the scheme turned out to be a failure, except that the use of its pan effects a slight saving in fuel. Donovan discovered its inefficiency, and has well explained it where he observes that through the loss of heat and the dissipation of the aromatic oil of the hop by continued boiling, the brewers employed an apparatus to arrest them in their flight, by adding a copper pan charged with water, at the top of the boiler, constructed in such a manner that the tube that allows the steam and oily vapour to escape, transmits both into this water, and heats and impregnates it with the oil at the same time, and the water thus qualified with volatile oil is used in the next mash; but he found that nothing was thereby gained, because the oil had already left the boiling wort, which was the evil to be prevented; and what is more unfavourable still, is the fact, that when this impregnated water comes again to the boiler in the new wort, it again evaporates, is expelled, and is received in other fresh water as before; so that the oil, though always in circulation, "*is never found where it ought to be.*"

Accum, who, though a rank pirate, was not always in error, points out the evil of boiling, in his Brewing Treatise, page 38. He saw that simple infusion extracted the aromatic oil, and that short boiling drew

out the bitter, but that long-continued boiling dissipated the aroma derived from infusion, and produced a predominant astringency by expelling the volatile oil in which the aroma resides, and extracting a tannin by its action on the coarser portion of the hop, the astringent nature of which was evident from its blackening sulphate of iron into an ink. Thomson, in his Vegetable Chemistry, adverting to the same subject, treats on the lupuline of the hop and of its examination by Payen and Chevallier, and says they found that it contained 13 *per cent.* of the cones in weight, 4 of which were foreign matter, so that the genuine lupuline was only 9 *per cent.*, and that when distilled in water, it yielded a colourless volatile oil, amounting to about 2 *per cent.* of its weight; which oil will dissolve in water in considerable quantity, and is the principle to which hops owe their peculiar smell. This volatile oil, then, which contains the active principle of the plant, as diastase does that of malt, is partly consumed by the act of boiling, and a bitter and griping nuisance is substituted in its stead. Surely something ought long since to have been devised to get rid of an evil, the virulence of which is increased by the boiling process.

But we must not overlook another oil, equally volatile, which is the resin of malt noticed in Chapter III., page 93, and now melted. Some of our indifferently rectified spirits possess a superabundance of this oil, which is clearly discernible on the addition of water. That the copper evaporates both this and the oil of hops is quite clear; and that the aromatic virtue chiefly resides in those essential oils, and emanates from them, is evident from that inherent principle of both plants which entitles them to selection, and is identical with their maturity and vital essence; and it is this essence that greatly contributes to the preservation of the spirit.

Having, then, pointed out one or two of the evils of boiling hops, the next question that naturally arises is, how to prevent such havoc; and how, above all things, to preserve their virtue and flavour. The remedy is simple, practical, and effectual:—this is

The Hop-Convertor.

This humble and unassuming invention, which is a part of the patent apparatus, lays the foundation of the economy which fermentation in its province perfects. The plan here proposed not only prevents an extreme evaporation of the aromatic and preservative particles, but extracts every atom of them, and efficiently incorporates them with the worts, while it rejects the coarse astringent matter that lies in the grosser husks and fibres of the hops. As the underback, according to the new system, will no longer be exclusively serviceable as such, the bottom part of it may be converted into a hop-back, such as is now wanted, by merely inserting a perforated floor above the old bottom; and in many breweries, the old hop-back plates can be transferred to the underback for this purpose. Upon the solid bottom of this new hop-back, or above it, but beneath the perforated plates, a coil or two of metal tubing must be placed, and be provided with a stop-cock, and made to communicate with the steam boiler.

The hops having been completely broken up and well divided, are to be laid evenly upon the perforated floor of the Hop-convertor, and at about four hours before setting tap, sufficient boiling water is to be run amongst the hops from an upper liquor copper or hot-liquor back, when it must be turned off. The hops are to remain in this state about an hour, within which time

their pores will be greatly opened, and the whole steeping will become thoroughly saturated with water. Recourse is then had to the steam apparatus before mentioned; the steam tap must be turned on, and the steam will then impart its caloric through the medium of the metal, till the liquor is raised to the heat of 200°, at which temperature it ought to be kept during three hours longer. This time will be quite sufficient to release the oil, the pollen, and the more soluble but less caustic portion of the tannin, without losing the aroma, because no vapour, or very little at most, has ascended, the heat having been kept 12° below the boiling point.

The steam-cock having accordingly been turned off, and the time having now arrived for setting tap, a few barrels of wort must be run into the Hop-convertor or underback; and when it stands at the depth of about six inches above the perforated floor, which depth should be constantly preserved throughout the time of extraction, the wort-pump, which formerly pumped the worts into the copper, must be put in motion, unless the underback is planted to command the coolers; and in that case, the hop-liquor, &c., will gravitate and fall upon the coolers. The first few lifts of the pump in the one case, and a short running in the other, will immediately convey this liquor directly to its destination to be cooled, leaving the hops in the possession of the gravitating worts, which worts will now pass through the hops and receive their remaining essence and virtue in the transit, and will then travel with the hop-liquor through the perforated bottom, and through the pump or tap to the coolers. As the mash-tun tap needs not to be turned off, the flow of water from the hot-liquor back through the sparger, the mash, and the Hop-convertor, to the coolers, will be continuous, washing and

floating the whole of the pollen, or nectareous farina, out of its native flower, away into the wort upon the coolers.

By thus impregnating the wort with the preservative parts of the hop, we not only effect a saving of that article, but likewise avoid the carbonisation or charring of the worts, besides an empyreumatic flavour, with the deep colour more or less consequent on boiling hops and wort in the usual manner; and it has been demonstrated that these evils have been increased where dome coppers have been used, because the worts have been exposed to greater heat by the pressure of the mis-called safety-valve. Presently, the subject of boiling in general shall be treated more at large; but hopping is the matter now under consideration.

Notwithstanding that the most valuable properties, and nearly all that are useful in the hops, are now incorporated with the wort that has passed through them, in order to ensure a complete extraction, it may be advisable, especially when porter and light ales are made, to retain the last few barrels that drain from the mash-tun after sparsion by the Hystricon, within the Hop-convertor, amongst the hops, and to boil them a certain short time by means of the steam-pipe; for the rankest bitter will then be either of little consequence, or will be disguised by the quantity of extract. This practice will be found very convenient, and in some cases even necessary; and the plan is in perfect conformity to the theory here propounded, because all the fine principles of both malt and hop are already secured on the coolers, and the density of the last extract is but little removed from water, if taken on the old plan, so that this partial retention of the boiling system may serve as an experiment, and will, it is to be hoped, make the Hop-convertor acceptable, even to the most dubious.

It should be understood, that by the plan of steaming hops through the use of the Convertor, coppers, underbacks, hop-backs, wort pumps, and shifting the hops, may be totally dispensed with, the new utensil being so located and provided, that the purposes of each may be accomplished by it with economy of materials, fuel, labour, and time; and we may further observe, that the Hop-convertor may be made, as a matter of course, to act the part of a copper or boiler; for worts may be boiled as effectually, and as long if necessary, by steam as by the furnace.

Steaming Worts.—As the requisite quantity of steam may be a question to some minds, and the mode of conveying it a difficulty to others, it may be necessary just here to observe, that the steam ought to pass as rapidly as possible from the generator to the boiling tubes, and through them, that little or none of the heat may be lost by radiation during its transit; for which object, the main from which the branches diverge, should be near the boiler or generator, and the latter as near its work as convenient. When the steam has a long way to travel, the conveying pipe should be surrounded by some non-conducting substance, to prevent a waste of its caloric. As the quantity of heating surface should be in proportion to the liquor to be heated or boiled, and to the pressure of the steam engaged, some idea of this subject may be formed from the fact, that 150 feet of two-inch copper pipe, in the form of a coil or distiller's worm, will heat 30 barrels of wort from 140° to 212°, in half an hour, at a pressure of about 40 lbs. to the square inch, and the same rule will hold good in other positions, so long as the same surface incloses the same space; and since circumferences are as their diameters, the surface heat will be inversely as the enlargement or contraction of the calibre. The rate of evaporation is

the same as with the furnace, if kept in the same state of ebullition.

This improvement and substitute for the old costly copper is now made of oak and cast iron, and lined with thin copper; and the steam is conducted through spiral chambers situated between both materials; and thus a greater heating surface is exposed to the worts; and the interior, when cleaned out, is smooth and free from obstructions.

In boiling by means of steam, not a particle of caloric needs be lost. The steam may make its way directly to the liquor-back of the sparging apparatus or of the barrel-washing liquor, and be condensed in either of them. By this contrivance the author has for several years conducted the practical department of his business without the aid of furnace heat, except of that under the engine boiler, that being the only fire in or near the brewhouse: thus the furnaces of three coppers have been dispensed with, as well as their stokers, at a saving of at least one-half in fuel, besides the wages. These are not all the advantages of an economical nature; for the very expensive wear and tear of brickwork, furnace bars, and coppers, are entirely avoided; and of the effects which the plan produces on the articles brewed, sufficient experience proves that it is incomparably preferable to direct furnace heat, both as regards colour and flavour, besides securing the permanency of the beer; but, like other innovations, no matter whether beneficial or not, it has to meet the opposition of certain interested parties, such as coppersmiths and the like, who know that this is a heavy blow at the most profitable part of their business, and have not hesitated to misrepresent the effects of steam boiling in the grossest manner, alike ignorant and barefaced, as it is insulting to men of sense and unbiassed perception.

Some few really intelligent persons have been led to doubt the efficacy of steam as a substitute for furnaces in the brewery. They have an indistinct idea that a proper effect is not produced on the worts by the heating powers of steam. To remove such apprehensions as arise from misconception and misrepresentation, we must here remark, that when all resistance, except the atmospheric, is removed from the surface of a boiling fluid, as brewers' wort in an open copper, for example, such fluids never attain a higher temperature than 212° or 213°, notwithstanding that the furnace imparts caloric of more than triple the intensity indicated by the thermometer when immersed in the boiling liquid, because all surplus heat above those 212° or 213°, flies off into the atmosphere. On the other hand, when water is exposed to furnace heat, and excluded from atmospheric pressure, as in the instance of a steam boiler, it will imbibe and retain caloric as long as the boiler resists its accumulating heat, and consequent increasing pressure. Hence steam is composed of fire and water in an intimate state of combination, which arises from compression, the heat of which bears a certain variable proportion to the resistance made to its escape into the atmosphere by the safety valve. The intensity of the caloric imparted to worts by steam may then be ascertained by the thermometer, the safety valve, or the mercurial gauge, all of which the brewer should provide, and particularly proper boilers for steam boiling and general purposes.

The following tables on the pressure and elasticity of steam, compiled from Luke Heber's Encyclopædia, will be of service to practical men who adopt the system:—

TABLE I.

Temperature by Fahrenheit.	Pressure of steam, or the force which it will exert to enter into a vacuous space.			Pressure of the steam against the atmosphere when the barometer is at 30°, or force exerted to escape from closed vessel.		
	Column of Mercury. Inches.	Column of Water. Ft. In.	Pressure per sq. in. lbs. oz.	Column of Mercury. Inches.	Column of Water. Ft. In.	Pressure per sq. in. lbs. oz.
212	30·	33 11	14 11	steam	equal to	atmosph.
220	35·	39 6	17 1	5·	5 7	2 7
230	41·75	47 2	20 7	11·75	13 4	5 13
240	49·67	56 1	24 4	19·67	22 3	9 10
250	58·21	65 9	28 8	28·21	31 11	13 14
260	67·73	76 6	33 2	37·73	42 8	18 8
270	77·85	87 11	38 1	47·85	54 1	23 7
280	88·75	100 3	43 7	58·75	67 5	28 13
290	100·12	113 1	49 0	70·12	79 3	34 6
300	111·81	126 4	54 12	81·81	92 6	40 2
310	123·53	139 6	60 8	93·53	105 8	45 14
320	135·	152 6	66 1	105·	116 5	51 7

TABLE II.

Elasticity in Atmospheres.	Height of Mercury in inches.	Temperature by Fahrenheit.	Pressure per square inch in lbs. Avoird.
1	29·92	212·	14·61
1½	44·88	234·	21·92
2	59·84	251·6	29·23
3	89·76	275·	43·84
4	119·69	293·4	58·46
5	149·61	309·2	73·07
6	179·53	322·7	81·69
7	209·45	334·4	102·30
8	239·37	343·4	116·92

The following suggestion, taken from Lance's Hop Farmer, page 18, has led to an improvement very likely to be of great service to the country, and will bring the use of the copper to a nullity, and that of the Hop-convertor to a very simple operation, when allowed to

be acted upon, besides saving, to the brewer at least, the odious expense of the coarse and heavy bags already noticed. "When there is a greater quantity of hops grown for several years than are likely to be used while they are good, it would be well to devise a plan for consuming them in those overstocked years. For the use of bittering beer, an extract may be made, and all the fine qualities of the hop retained in a liquid state, or the bittering principle concentrated in a dry state of powder, and thus preserved, may be sent on board ship for exportation, or conveyed to any part of England in air-tight vessels: this would be the means of saving much room on shipboard, or in warehousing a stock. The quality of bark for medicinal purposes is now concentrated into a small compass, as *quinine;* and why not the bitter principle of hops? Instead of one pound of hops to a bushel of malt, part of an ounce of extract would then be sufficient, particularly if the extract was made with spirits of wine. A tincture of hops may be made with part water and part spirits of wine, and subjected to a gentle heat for a few days in an air-tight vessel: the full virtue of the hop will be thus extracted, and the virtue of several hundreds weight be concentrated in a gallon of liquor: this would be the tincture of lupuline, and would act as a medicine, or might be used for flavouring beer." Such are the pursuit and spread of literature and art in the present age, and the facility and rapidity of intercourse between and among nations, that no sooner is an idea started in one country, than it is scrutinised in another, and if worth anything, is immediately seized and acted upon; and accordingly within the course of two years, Mr. Lance's opinion travelled into France, unless a coincidence of thought sprang up there at the same time, received an impetus

there, and having been tested, is put into practical operation, patented, sent home again, and has obtained a patent in England. This is doing things cleverly and expeditiously; and here follows our translation:—

"An important problem relating to the cultivation and commerce of the hop, and to brewing, has been solved by the discovery of *humuline*, for which the house of Heck & Co., at Bischville (Lower Rhine), and at Nancy (Meurthe), have just taken out a patent for ten years.

"Humuline is the active principle of the hop, separated from all its inert matter; this product consequently represents the hop with all its properties in its natural and unadulterated state.

"It is *destined* to take the place of the hop in commerce and in brewing, for it possesses over the natural plant very great advantages, of which the following are the principal:—

"The hop loses its good qualities from year to year, and in the course of two or three years becomes unsaleable: humuline, on the contrary, prepared according to the patent, will keep for many years without expense, and without the least alteration.

"The hop is a bulky article, requiring extensive warehouses, and to be protected from the weather: humuline, on the contrary, takes up but little space, and is preserved without loss in any warehouse or cellaring.

"The hop, if sent to a great distance, is often liable to injury from heat or wet: nothing of the sort is to be feared for the humuline, which may be easily carried in any weather, and at much less expense.

"The proportion of the active principles which the hop contains, varies every year and in every country, to

such a degree that the brewer is never sure of the result that will be obtained from the first brewing made with any particular sort: by substituting humuline, he is certain of the result being always the same, and constantly favourable. Hundreds of brewings already made in many places, and by numerous brewers, have effectually proved it. The beer from humuline is shewn invariably to be superior to that made from hop.

"The small space which the humuline occupies in the boiler, increases the quantity of the beer, and lessens the firing. In a word, brewing, usually so complicated and so uncertain, becomes with humuline an operation simple, sure, and of easy execution.

"One kilogramme of humuline is equal to three kilogrammes of hops of the best quality; and in that proportion the humuline must be used by the brewer.

"We offer to merchants and brewers the humuline obtained from the hops of Spalta, Bohemia, Germany, Alsace, Lorraine, &c. &c., with scarcely any increase of prices above the hop from the same places. We guarantee besides to the brewers complete success in the trials with humuline, if they will attend to the simple directions with which we will furnish them.

"It must be observed, that our humuline may be used for the making of every kind of beer, whether Strasbourg, Lyons, Paris, English, &c. &c., and there will be a remarkable saving of time in each brewing.

"HECK & Co."

"*Directions for using the humuline.*

"Take one kilo. of humuline instead of three kilo. of hops, add it to the wort about 30 or 40 minutes before drawing it off from the boiler, allowing it to boil gently,

and keeping the boiler covered. After this the brewing is done in the usual way.

"According to the capacity of the boiler, you may add one-half, or one or two kilo. of hops. This small quantity is to attract the little flakes floating in the beer, and that it may run quite clear to the cooler.

"Brewers wishing more information, address Messrs. HECK & Co., Bischville, Bas Rhine."

In the Mechanics' Magazine, No. 943, p. 206, notice is taken of an extension of the French patent to England, granting it to William Edward Newton, of Chancery-lane, London. Mr. Newton dries his hops at a temperature of 86° F., till they become brittle, and assume a pulverulent character, and then they are passed through a coarse sieve; he next places the powder in a close cylinder, covers it with alcohol an inch and a half deep, presses it close for 24 hours, and then draws off the alcoholic tincture into a tub, and the powdered hops are washed till no extract is left within them. The essential oil is thus combined with the tincture, and being placed in a warm bath, the alcohol is driven off, leaving the oil, which resembles a yellow resin, covered with a lutean aqueous liquor, and the extract and watery solution are evaporated together over an open fire till they become syrup, which is removed to the water bath, and farther evaporated till it is nearly solid, which he unites with the resinous matter of the alcoholic tincture while warm, and these form humuline, one pound of which is equal to three of hops.

As regards the process, it appears at sight to be chemically correct, and that the matter so produced will answer the brewer's purpose admirably, because of its economy, and the facility with which it will dissolve in

the worts and unite with them; and for these reasons the author inclines to the idea that where a little astringency is not of consequence, as in porter, vatted ales, &c., it may be expected to rival the Hop-convertor.

All that is necessary for the preparation of the humuline seems to be nothing more than a little moisture and heat, in order to add it to either the raw or the fermented wort with ease and accuracy; thus we have another and perhaps a cheaper method of impregnating the worts with the essentials of the hop, and also another substitute for boiling and spoiling the extract of malt.

If humuline were manufactured from English hops under the eye of the excise, and marked by them as the produce of hops which have paid the duty or are charged with it; and if it were *permitted* by them like other excisable commodities, the officers of the revenue could not have cause for interference, notwithstanding any "rusty act of parliament" which designers might rake up; and at all events, they cannot obtrude upon private individuals; for if the object of any interposition on their part be to exact a second duty, or a penalty in lieu, it is austere and intolerant; but if it is to be otherwise prepared than as here pointed out, there is no safety in guaranteeing a plan to prevent adulteration. The excise would at once mark the locality of the manufacture upon the packages and would seal them; so that the brewer would know whether he was buying Kents or Worcesters, Sussex or North Clay, and consequently whether he was to use 3 lbs. or 4 lbs. to a wort of given density and gravity; and besides, they would also mark the date of stowage, and having ensured the maintenance of the desirable qualities of new hops, the deceitful practice of returning old ones to be mixed with them would be abolished; indeed, old hops

and bagging might be superseded altogether by this plan, and the usual consequent deterioration would be avoided through concentrating and preserving new essence only. The humuline may likewise contain the extract of the bruised seeds, which will materially alter its taste; and the "hop-dust" which is found to have escaped from the leaves and to be deposited under the drying oast, may be concentrated within it, if parties are so disposed; all which things ought to be known and understood; and another question arises, though we have no right to anticipate adulterations, aware as we are of their common occurrence; for some men are born to stratagem and finesse, move how and where they may. Though it will do away with the odious practice of selling coarse sackcloth at hop price, will it banish for ever the fraud of smoking the hops with brimstone? Will it prevent infusions of cockle, (*agrostemma githago*,) darnel, grains of paradise, and savine, juniper, or "kill-bastard"? Will it abolish wormwood, southernwood, yarrow, buckbean, chamomile, centaury, broom, or gill? Will it prohibit the importation of gentian-root, quassia, tobacco, chirayetta, or ginseng? The author has a fixed antipathy to adulterations of all kinds, and especially to such as are *pernicious;* so much so, that he feels disgust and harsh contempt at the idea of them. He would of course introduce quassia, tinctured a little with gentian, (for of itself it is too stale and inodorous,) when hops could not be obtained, and then only as an inevitable expedient; and in that extremity chirayetta might be tried, subject to the connivance or relaxation of the law, which in such an emergency ought in reason to be suspended for public accommodation in a definite degree.

In buying samples of hops, a little boiling water may be poured over an ounce or so, in a vessel with a close

lid, and left to stand a few hours; and the same may be done with various samples at once, and at the end of that time they will distinguish themselves by the mere difference in the taste and scent of each:—may humuline stand the same test! Wormwood, as we have seen, will produce a brilliant and most pleasing beverage, and is highly admired when first tapped; but if afterwards allowed to stand a few days, it becomes flat, and is loathsome in the extreme, and adulterated humuline would perhaps do the same. Mr. Newton, as English patentee, would in that case only have to see that his agents and workmen did not take liberties with his instructions; but unfortunately, the present state of the excise laws precludes the introduction of humuline into the British brewery; and though a company of speculators in London, with Dr. Ure at their head, are essaying to form a large capital to trade in the "concentrated essence of malt and hops," they will probably find a prohibition put upon the produce of their ill-bestowed ingenuity. (See the "Economist of June 14, 1845," where applications for shares in the "National Brewery Company," capital 500,000*l*, are to be made to Andrew Ure, 13, Charlotte Street, Bedford Square.)

That the produce of the hop is exceedingly fluctuating and precarious, the following table of prices and quantities will evidence. The list has been carefully compiled from the official returns made to Government at the end of each year during a period of 20, from 1823 to 1842, inclusively. The duty charged is the old standard of 4·6 farthings or 1·15 penny *per* pound, or 10*s*. 8·8*d*. *per* cwt.; but the present duty, since the passing of the 3d of Victoria, c. 17, is 2*d*. *per* lb. or 18*s*. 8*d*. *per* cwt. with 5 *per cent.* in addition, making 2·1*d*. *per* lb. in all, which gives 19*s*. 7·2*d*. *per* cwt.

Anno Domini.	Acres grown.	Amount of old duty paid.			Duty paid per acre.			Quantity grown each year.				Growth per acre.		
		£	s.	d.	£	s.	d.	Tons	cwt.	qr.	lb.	cwt.	qr.	lb
1823	41,458	26,058	11	9¼	0	12	6¾	2,427	16	1	14	1	0	19·2
1824	43,419	148,832	0	0½	3	8	6¾	13,866	6	2	25	6	1	15·3
1825	46,718	24,317	0	11½	0	10	4¾	2,265	11	1	2	0	3	24·6
1826	50,471	269,331	0	9½	5	6	8¾	25,092	19	0	9	9	3	21·7
1827	49,485	140,848	4	2¼	2	16	11	13,122	10	0	9	5	1	6·
1828	48,365	172,027	10	11½	3	11	1¼	16,027	8	0	25	6	2	14·3
1829	46,135	38,398	10	7¾	0	16	7¼	3,577	10	0	7	1	2	5·7
1830	46,726	88,027	8	1½	1	17	8	8,201	6	0	25	3	2	1·2
1831	47,129	174,864	10	1¾	3	14	2½	16,291	14	1	26	6	3	18·4
1832	47,101	139,018	4	3½	2	19	0¼	12,952	0	0	17	5	2	0·
1833	49,187	156,905	7	0	3	3	9½	14,618	10	0	24	5	3	21·7
1834	51,273	189,713	14	2½	3	14	0	17,675	3	3	6	6	3	16·2
1835	53,816	235,207	2	11¾	4	7	5	21,913	14	0	21	8	0	16·1
1836	55,422	200,332	12	11¾	3	12	3½	18,664	10	2	17	6	2	26·5
1837	56,323	178,578	3	10¼	3	3	4¾	16,637	14	1	16	5	3	17·7
1838	55,045	171,556	8	10	3	2	4	15,983	10	1	15	5	3	3·4
1839	52,305	205,556	13	7	3	18	7	19,152	9	3	13	7	1	8·2
1840	44,085	34,091	16	1¾	0	15	5½	3,176	5	0	12	1	1	21·4
1841	45,769	146,159	1	6	3	3	10½	13,617	6	0	11	5	3	22·4
1842	43,720	169,776	6	0	3	17	8	15,817	13	1	12	7	0	26·4
Average of 20 yrs.	48,697	145,480	0	5½	2	18	7½	13,554	2	0	4	5	1	23·7

The above corrects a portion of a printed circular issued from the office of Mr. S. Plimpton, Jun. hop-factor, of Mark-lane and Maidstone, whose figures are copied in the three first columns and taken as granted data, or, as he says, they "may be considered as very nearly" the truth. The fourth column is a mere division of the third by the second, to show the fluctuation on a smaller and more striking scale to the common observer; and the fifth is obtained by reducing the several items of the third into pence, and afterwards dividing each by 1·15 to find the numbers of pounds grown, which are again reduced into tons, &c., but which he has not been careful enough to do, and has thereby committed considerable error in his results; for by retaining the cwts. and again dividing by the acres planted, the last column is fairly and clearly obtained, every number in which is

lower than his by 3 qrs. 6 lbs. on the annual average, shewing that he rates his charges for duty too low, and estimates his acreage growths too high. Taking, for example, the years 1825 and 1826, which were as remarkable as any in the scale, he deduces the growth *per* acre to 1 cwt. 8¾ lbs. in the former season, and to 11 cwt. 5½ lbs. in the latter; that is, to 120¾ lbs. and 1237½ lbs. respectively; which being multiplied by 46,718 and 50,471, the acres cultivated in the two years, give the gross growths 5,641,198½ lbs. and 62,457,852½ lbs.; then dividing the numbers of pence paid as duty, 5,836,091*d.*, and 64,639,449½*d.* by those pounds of produce, the results are 1*d*·034548 and 1*d*·034929 duty *per* lb., or 9*s.* 7*d*·869 *per* cwt. paid in the scanty year, and 9*s.* 7*d*·912 in the prolific year, instead of 10*s.* 8$\frac{1}{5}$*d.*, and so of the rest, some of which vary more widely than these.

The carelessness with which tables are generally constructed for the guidance of the less skilled in arithmetic, is really appalling; so much so, as frequently to induce suspicion in the minds of the conversant, that the framers of them are not competent to the undertaking. The "Brewer's Annual" gives the following as the amount of hop-duty charged for 1843:

	£	s.	d.
"Old duty at 1$\frac{18}{20}$*d. per* lb.	133,431	11	1
New duty at $\frac{3}{4}\frac{8}{20}$*d. per* lb.	98,623	6	5
Additional duty of 5 *per cent.* *per* 3 V. c. 17	11,601	16	11
Actual amount of duty	243,656	14	5"

But admitting the total to be right, all the three items are wrong, the first and second being over-rated, and the third under-rated, as the subjoined analysis of the

several districts or collections will show. A scruple may be raised, that a few shillings are not of consequence in a matter of such magnitude; but a cool calculator will reply to this, that none but a bad clerk keeps incorrect accounts, and that he who blunders in his pence and farthings is liable to err in his pounds and balances.

DISTRICT.	Old duty paid at 4·6 farthings for each lb.				New duty paid at 3·4 farthings for each lb.				Additional duty at ·4 of a farthing for each lb.				Total amount of duty collected.		
	£	s.	d.	32ds.	£	s.	d.	32ds.	£	s.	d.	32ds.	£.	s.	d.
Rochester . . .	40,452	12	5	28	29,899	15	3	28	3,517	12	4	28	73,870	0	2
Canterbury . .	32,916	5	11	36	24,329	8	9	12	2,862	5	8	36	60,108	0	6
Sussex	44,601	2	8	12	32,966	1	1	18	3,878	7	2	12	81,445	11	0
Hampshire . .	2,839	6	9	34	2,098	12	10	16	246	17	11	34	5,184	17	8
Isle of Wight .	1,827	9	6	5	1,350	14	10	11	158	18	2	26	3,337	2	7
Hereford . . .	6,949	6	5	37	5,136	9	1	31	604	5	9	16	12,690	1	5
Worcester . . .	704	18	10	15	521	0	10	33	61	5	11	36	1,287	5	9
Stourbridge . .	161	3	7	34	119	2	8	16	14	0	3	34	294	6	8
Essex	641	19	4	26	474	9	11	32	55	16	5	26	1,172	5	10
Suffolk	500	16	4	38	370	3	5	8	43	10	11	38	914	10	10
Lincoln	908	15	4	3	671	13	11	15	79	0	5	24	1,659	9	9
Other places . .	927	3	7	15	685	6	1	33	80	12	5	36	1,693	2	3
General totals	133,431	1	2	31	98,622	19	2	1	11,602	14	0	10	243,656	14	5

Consequently, the bungling "Annual" has an overcharge of 9*s.* 10*d.* in the first duty, and of 7*s.* 3*d.* in the second, and an equivalent undercharge of 17*s.* 1*d.* in the third. But this is not all; for by the return of Excise and Customs Duties, ordered by the House of Commons on the 8th of March, 1844, and printed on the 21st of June, and signed "G. A. Cottrell, Accountant-general," the hops charged with duty for the year ending January 5, 1844, weighed 27,862,730 pounds, and produced a revenue of £243,798 17*s.* 9*d.*, which is, of course, at the rate of 2*s.* 1*d.* *per* pound.

An important observation is here required, to the effect that the quality of the hop depends upon the season, and not always on the soil or district in which it grew; though the truth is, that the species denominated Goldings, cannot be grown in the Weald of Kent

and Sussex, because the geological formation of a stratum of clay near the surface, will not allow the roots to descend; whereas "Grape" hops obtain their nourishment near the surface, and therefore succeed well there. Hurricanes and disease will affect one part of a county, though another may escape them, whether sheltered or elevated, and the strong plant may suffer as much as the more weakly; so that it is an error to imagine that East Kents are uniformly preferable, and it would be wrong in any person to guarantee their superiority.

CHAPTER IX.

BOILING.

REFLECTIONS—THREE GREAT PRINCIPLES—EVIDENCE OF LOSS—ECONOMY—NEW LONDON MODE—THE FLAKES EXAMINED—THEIR COMPOSITION AND VALUE—EVILS OF BOILING—INUTILITY OF DOME COPPERS—DESTRUCTION OF DIASTASE—ANTI-BOILING—YIELDING OPINIONS—PRACTICE—PRESERVATION OF ALCOHOL—IMPROVEMENT OF FLAVOUR—LOSSES BY IMBIBITION AVOIDED—ADVICE ON BOILING.

"Before you give way to wrath," saith an old precept, "try to find a reason for not being angry;" and with equal consistency we might urge a moral in softer language, not to raise objections to a novelty merely because it is new, lest it should prove to be old or valuable; but to endeavour to see some cause for the restraint of criticism, and pause before we condemn, thereby to shew that we are not more censorious than politic. There are in society certain creatures who value no person's opinion, however fully matured, so highly as their own, although it be useless and obsolete; for ignorance is ever unconscious of being ignorant, and long-conceived notions grow into habitual prejudices. Obstinacy is so blind, as not to see anything sublime until dazzled with the effect of sublimity, and overcome by its power; like the hog, which knows not the value of saturated grains, except that they appease his appetite, though they may, unfortunately for his master, inebriate him, bringing on insensibility and lethargic stupor. Were our ancestors to return to our cities, and behold the splendour of the

gas-lights that illuminate them; or into our fields and roads, and there witness the rapidity of the steam-propelled and pneumatic railway trains, they would indeed wonder at the impudent moonshine produced from coal smoke, in imitation of that which in their day was a child's trick, and at the stupendous innovations that have grown out of a simple experiment with a tea-kettle spout, or the pressure of a pair of bellows! In the same retrospective light may be viewed some of the notions that have been entertained with respect to aërostation, vaccination, geology, and many other inventions and discoveries, and especially in almost every instance, those advancements in the arts and sciences for which letters patent have been obtained (whatever pecuniary and mental expense, without hope of remuneration, may have attended their completion), in order to stimulate industry; to economise time, labour, and fuel; to determine, regulate, and exemplify the powers of genius; to expand the views of experimental science; and to beautify the niceties and remove the intricacies of art: in short, to throw open the doors of philosophy to all who choose to enter, to improve and impart knowledge. If the inventor of the air-balloon was called a "wild goose," the discoverer of the vaccine lymph a "calf-head," the projector of the locomotive engine a "hair-brain," and the practical propounder of carburetted hydrogen gas as a light, a "lunatic," scarcely can the founder of a matter so simple as the theory of brewing the national beverage without boiling it, however beneficial to society his product may be, expect to escape the opprobrium of some visionary epithet, and particularly from traders wedded by antiquity to an old state of trade, quite uncongenial to those who would march forward in the high road of sweeping improvement: he has, however, as he perceives from a little experience,

his open abettors, who declare their conviction; and if he can be fortunate enough to demonstrate to the ordinary capacity of man, by proofs at once clear, uncompromising, irrefragable, and permanent, that he is guided by cool reason and thoughtful solicitude; that, in fact, he is right, and the customary practice wrong (upon which point he yet stakes his reputation as a brewer), he will be pleased and satisfied at the gratifying idea of having inserted his little tenacious link in the interminable chain of intellectual expansion, and contributed his mite towards regulating the equipoise between the scales of commercial justice.

In the preceding account of the Mashing Attemperator and the Hystricon, it has been explained that the grosser portions of gluten, albumen, and gum, are retained in the grains, as they will not pass through the filter: their finer parts, however, which are considerable, are dissolved, and are so far blended, and in a measure identified, with the sugar, that their separation from it, while in that state, is impracticable by ordinary means; and this shews the necessity of their conversion into sweet, or of their removal from the body of the beer; and nothing but a cool and slow fermentation can afford time for their disengagement, and prevent their effecting a wrong species of decomposition of the sugar or its produce; and again, as the most grateful flavour is obtained from the most delicate parts of the materials, and as these are the finest, the richest, the most subtile, and the most liable to evaporate, even from the first; the warmer the circumambient air, the more greedily it absorbs in its thirst those delicate and volatile constituents, which, from these causes, it is essentially necessary to preserve through the intermediate stage of incorporation with the hop.

Though the new mode of impregnating the worts

with the aromatic and preservative principle of the hop, differs from the usual, and indeed the universal plan of boiling pursued in the English brewery, the anti-boiling system is not entirely new; nor is the manner of extracting and preparing the essence of the hop, though the united process be novel, speedy, and economical, and the effusion of ideas altogether unique; for like the former operations, described as parts of the inventor's scheme, its necessity has been seen and felt: the why has been in some measure accounted for; but the how has been wanting; and when discovered, it is found to carry out the great principles of—

I. Economy in Fuel;
II. The preservation of the Alcohol; and
III. The improvement of the Flavour.

I. Economy in Fuel.

In the first place, then, by dispensing with the boiling system, the fuel saved by the use of the Mashing Attemperator and the Hop-convertor, is a consideration so important in a pecuniary point of view, that this saving alone ought to weigh well with those whose capital has been expended in support of a process which has caused it to evaporate—the principal in the coal mine to produce fire, and the interest in the atmosphere in the state of smoke, inflicting injury upon their neighbours, without any benefit to themselves.

The avowed reasons, or rather the excuses, which are given in favour of boiling, are vague, contradictory, irrational, and unscientific; and to those who seriously reflect on its consequences, it is a matter of real surprise that the practice, with all its disadvantages, has continued so long; yet the mode of extraction and fermentation hitherto pursued, may have, to a certain extent,

urged its necessity. It is, as the author knows and will prove, wasteful and pernicious, both to the extract of the malt and to that of the hop; for when the worts are heated to the boiling point, they undergo great agitation, and their ebullition causes the escape of much superfluous heat, accompanied with particles of the liquor, and the finest portion of the malt and hop. This great loss must be evident to the olfactory and other senses of all who pass within a few hundreds of yards of the brewery at any time, or within the extent of half a mile to the leeward of the copper when the operation is going on, as its fine aroma, the great essential of flavour, passes through their nostrils and over their palates. This is rendered still more strikingly evident when equal quantities of boiled and unboiled worts of the same specific gravity, are completely attenuated by a correspondent process of fermentation, and are afterwards subjected to distillation. This experiment, at the same time, again shows that the saccharometer does not at all times detect and correctly indicate the amount of *all* the fermentable matter present in either raw or boiled worts; for the fruits of much seemingly disguised matter in impure worts are developed by the still, and alone made apparent by the hydrometer.

Although some persons will be so bold as to contend that nothing flies off except watery particles, and that no loss accrues to the fermentable matter, but that boiling is necessary for dispelling the air; if such persons would only take the trouble to put their assertions to an unbiassed and fairly-conducted trial, as before alluded to, they would assuredly find that a considerable portion of the fermentable extract of the malt is lost by boiling the usual time; and let it be remembered, that the loss is more severe, because the most delicate and valuable of the aromatic particles of the two principal

materials are thus lost and annihilated by dissipation and carbonisation. As to the secondary object, the expulsion of the air, it has not yet been shewn that a wort deprived of its native air, ferments more kindly, or makes better ale in any one respect, than one which possesses a moderate quantity of air, such as is usually found in water. On the contrary, it would be highly advantageous in low fermentations, or where it is desirable to pitch at low heats, and make full-bodied and finely-flavoured ales; for such malt liquors would ferment the more readily, and continue in the fermenting state the more vigorously, at any temperature, because not deprived of their constitutional strength. At the desirable low heats especially, while other less aërated worts would scarcely evince a motion at many degrees higher, this advantage is decidedly manifest. They who prefer such languid and imperfect fermentations as long or even short boilings originate, may, however, avail themselves of the value of the new plan, by boiling their liquor previously to mashing.

Perhaps, though neither much good nor any very considerable harm is done in this respect by boiling worts or liquor at certain periods of the year; that is, when they lie upon the coolers just long enough to absorb as much air as has been lost by boiling; this compensatory effect is uncertain, and cannot at any time be relied on; since at one season, during cold weather, the worts would regain but little; and at the opposite extreme of summer, they would draw in considerably too much, especially when the temperature of such worts is down at 80°, or perhaps at 90°; for the imbibed air always contains more oxygen than was expelled; and hence arise spontaneous fermentation, the fox, premature acidity, and many other evils. The writer would remark, too, that the boiling of either water or wort,

causes a deposition of saline compounds, principally consisting of carbonate or sulphate of lime, thus wasting a most valuable anti-acid, the excellence of which is established above, in Chap. IV., p. 116, &c. Why should the country be ransacked in search of barley, hops, and water, all containing this and other kindred salts, for the sake of their preservative goodness, to have it galloped away in the copper?

Again, referring to Einhof's analysis of barley-meal, and setting aside the little niceties of distinction made by analysts among the different phosphates and other salts, arising, perhaps, from differences in the quality of the land and manure in which the corn had grown; as the meal in the experiment was just $\frac{7}{10}$ths of the whole bulk, and 2690 parts of it, produced from 3840 of barley, gave as follows:—Volatile matter additional 252, albumen 30·8, saccharum 140, mucilage 123·2, phosphate of lime, &c. 6·3, gluten 95·5, husk additional 182, starch to make saccharum 1806, loss 53·2, fractions, chiefly starch, 1; total 2690. This reduces the whole of the first barley, after the second separation, to—

Volatile matter	17·76	Gluten	2·5
Starch and saccharum..	50·68	Phosphates, &c.	0·16
Albumen, about........	0·81	Husk	23·49
Mucilage	3·2	Loss	1·4

Thus, by the simple act of crushing before the test, we have, on a very particular examination, 14 *per cent.* more saccharum, or of starch fit for saccharisation, than Proust, in his analysis of crude barley, though 20 *per cent.* less than when barley, but probably not the same, is malted, which is 16 less than in Thomson's result; the gluten, which Proust gives at 3 in barley and 1 in malt, Einhof finds to be 2·5 in the middle state; but the mucilage, which appears to increase from 4 to 15 in malting, is, with the albumen, only 3 *per cent.*; yet then, we have

here no less than nearly 18 *per cent.* of rich "volatile matter," subject to flight or injury the first time that it is heated beyond the ordinary endurance: a certain proof that too much fire is a dangerous thing in a brewhouse.

Grain distillers do not boil their worts; yet their method and object in the mash-tun is similar to that of brewers; still the extreme perfection of their fermentation is here worthy of remark. They can easily attenuate to the lowest point, even to the specific gravity of water, because they have not removed the necessary agents by boiling; their high fermenting heat being merely to facilitate the process; the flavour of the saccharum not being with them a consideration, since they attenuate all the saccharum, and nearly all the vegetable matter.

Neither do cider makers boil their must, and yet it ferments well, is clear and sparkling, and keeps well if properly managed. The author had a conversation with one of the most conversant of the practical London brewers in which this topic was discussed; but he has been so long accustomed to boiling, that he cannot see how to dispense with it, though he candidly admits that "too much boiling does harm;" and it may be somewhat worthy of remark, that the same gentleman has ventured to abolish the use of the copper, and to boil his worts by steam, according to the manner explained in the foregoing chapter, in a back erected for that purpose; which plan is now followed by other brewers in the metropolis and elsewhere, to the extreme mortification of the coppersmiths; whether they will next run their first worts upon the coolers unboiled, as a second tardy step towards the plan adopted in the mind of the patentee and successfully carried out, he does not attempt to predict, though many have become

aware of the existence of a vital evil, and yet are unwilling to break through the trammels of habit, but rather

> "To hint a fault and hesitate dislike,
> Willing to wound, and yet afraid to strike."

For why is wort boiled at all? To extract the bitter, most assuredly; and this is now done by means of the Hop-convertor, without any risk of losing the prime materials.

The same experienced person above-mentioned, in objection to the introduction of an anti-boiling system, reasons upon the practice of country ladies, who in their domestic economy as practical housewives, contend that their *preserves* will not keep in a sound condition unless they are boiled. Neither, be it observed, would those prepared with honey by the women of the 13th century, nor are we anywhere informed that their ale was boiled more than their mead or metheglin; but in order to remove any prejudice that may be formed on such an inference, we must reflect that the fixed air and the vigorous gluten, &c. of the unboiled fruit extract is prone to the acetous fermentation, and hence its unsoundness. Boiling, in that case, will retard the decomposition, by expelling the fixed air and its superfluity of water, and by crippling the decaying energies of the albumen and other native matter that constitutes its ferment; therefore, we may grant that such will be the effect on substances containing similar properties, in proportion to the caloric they imbibe, though whether boiling, even if adequate in that instance, be a desirable means, remains to be proved. As a simile, it is not a good one, because boiling is no preservative of fruit unless *sugar* be added, and because there is an additional and extraordinary property latent

in the brewer's wort which was never intended to exist in the preserve, and a purposed fermentation is essential to its existence, wherever it be produced: that property is alcohol. Besides, the remaining ferment and the vegetable matter are reduced in quantity and power by the fermentation; and even before boiling, were considerably less in proportion to the bulk of each article containing them, or rather, in proportion to its specific gravity; and the alcohol is itself a well-known preservative to the remaining extract; whereas in the preserve no fermentation is intended, nor is any defensive alcohol provided. The gentleman admits that boiling is not necessary for the impregnation of the wort with the hop, and the mode of converting hops by steaming the liquor, will answer quite as well, or better; for what purpose is wort then boiled? He says that unboiled worts will not keep, having tried them. The author has no desire to contradict the affirmation, not being acquainted with his process of treatment in the mash and fermenting tuns, or out of them; but he can truly assert, on his own part, that his duly attempered worts keep much better under his own treatment, by which all azotised ingredients are ultimately removed, than any boiled worts on which he has ever acted; and he has tested them most rigidly.

II. The preservation of Alcohol.

Amongst other objections which it is possible to raise against the novel conversion of the hop, as a great innovation on the habitual and long-continued practice of boiling, is this, and perhaps it may be the most general, namely, that the effects of boiling are *seen* in the flakes or flocks that are produced by the coagulation of some vegetable substance contained in the malt or the hops, or both; and that by their appearance the quality of

the material is tested and ascertained; but it has not been satisfactorily shewn by any writer on the subject, that an increase of their number or size is advantageous, or yet that their production or continuance is desirable; for in all probability the question has never been fully investigated, nor do chemists seem to have decided what they are; and much less satisfactorily, therefore, can they discuss the mode of treatment and determine upon it. At all events, they consist of coagulated substance; but whether it is gum, or mucilage, or gluten, or albumen, or whatever else it may be called by way of speculation, beyond what is herein seen on the authority of philosophers, but all aiding in the solution of the same question, they assuredly are the effect of excessive heat. If their accumulation be a high merit in the art and mystery of brewing, they may easily be produced without either overboiling or legerdemain; for it is now many years since the author discovered, without study, that one ounce of powdered quicklime *per* barrel, added to the wort when ebullient or *hot*, caused ten times more flocks to form in ten minutes, than three hours' boiling could produce. He is well convinced, too, that a very great majority of these flakes or flocks escape with the wort through the hop-back; and as it parts with its caloric on the cooler, so do they again partially dissolve, and cause that turbidity so discernible in cold worts, notwithstanding their great transparency when hot. Were it possible for this to be a mistake, it cannot then be denied that they find their way into the fermenting tun, and are never afterwards seen in their pristine state; for being of a vegetable nature, and highly charged with nitrogen and sugar, they submit to the influence of the fermenting mass in which they float, and undergo decomposition, one of the products of which must necessarily be alcohol; for the agitated

particles and constant commotion of escaping gases will not allow such very light matter to subside, unless under peculiar circumstances.

One author, after advising a gentle first setting of the tap in order to obtain bright worts, finds it necessary to suspend a bag made of horse-hair or thin canvass, filled with hops, in the under-back, as an effectual preventive to acidity taking place in the wort, which is a common occurrence in hot weather, and will sometimes happen in a moderate season; but whether brewers boil their hops in suspended nets, whether they rouse the hop-back, as recommended by another, or whether they use backs without false bottoms, plugs, or taps, as done by a third, or whether recourse be had to any other of the expedients usually practised, their system redissolves the flakes with the watery parts of the wort, so that they fall into a state similar to that in which they were before boiling, but with the exception that they are injured in quality, partially carbonised, and deprived of some of their useful air, and consequently they will be longer in decomposing. Combrune was aware of some of these consequences, and therefore boiled his worts without the excuse of ignorance, and his words are not a little remarkable: "Those who continue boiling the first wort a long time, do so in order to be satisfied that the fire has had its due effect, and that the hops have yielded the whole of their virtue. They judge of this by the wort curdling and depositing flakes like snow. If a quantity of this sediment is collected, it will be found to the taste both sweet and bitter; and if boiled again in water, the decoction will ferment when cold, and yield a vinous liquor. The flakes, therefore, contain a part of the strength of the wort; they consist of the first and choicest principles of the malt and hops, and by their

subsiding, become of little or no use." Here, then, is one who wrote with his eyes open; and who, rather than lose the gratification of knowing that the fire had taken its "due effect," was content to sacrifice the "first and choicest principles," so that they became "of little or no use." Glorious inconsistency! not of the man, but of the school.

From the great quantity of matter partaking of the flaky form, and which brewers delight to "see curdle," the idea of its being all gluten seems to be contradicted by analogy, since Proust's experiments give only one part of it in a hundred in the whole corn before mashing, and still less after a further change effecting a saccharisation of starch, &c. Of what, then, do these flakes consist, that they can be so readily obtained, and in such abundance? Not of mucilage, from the clearness of the fact that it will not coagulate under such circumstances. Chemists certainly are inconclusive upon this point; but as Einhof's analysis of barley and barley-meal has led to the detection of albumen, and to its introduction among us in its true character by Thomson, this may help to make up the apparent anomaly, which we shall the more clearly see on referring to the second chapter of the present treatise, and especially to *gum* and *albumen*.

Now if it be wished to coagulate the albumen by way of experiment, in order to expel it out of the body of any certain wort, let the heat of the mash be increased to 190° or 200° just before setting tap, and the after-process will filter the wort at once, and render it tolerably free from this or other flocculent matter; but another subject for enquiry is, what good will their expulsion effect at this stage? If they do not consist of albumen, then they must contain some other constituent of gluten, or be compounded of two, with such grosser por-

tion of the essential oils as the ebullient force of heat could not evaporate, and which necessarily, from their lightness, must find their way to the surface during the agitation by which they are loosened from their hold when boiling; but albumen has been shewn to contain the prime motive principle, gluten to possess the nitrogen of vegetables, and the oils to hold the odour and much of the richness of the substance that contains it, and to unite freely with sugar; and moreover, from what has been advanced, the elements of albumen are in some cases due to the diastase which inhabits it, and which is the prime agent and central principle of its existence, and of life and motion in the whole mass, whether maltine or lupuline; and hence the absurdity of boiling it away! But let us clear up the subject otherwise.

We glean from Biot, Persoz, Pelouse, and other continental chemists, the part which diastase performs when in communication with starch, as already rather fully detailed, with some little assistance in accounting for such large bodies of flakes; and they also describe to us some little utility in a diastatic or mash-tun Attemperator; telling us of that valuable discovery which shews that the starch of malt exists in numerous globules, which its action speedily dissolves; but whether or not we may attribute the accumulation of these flakes and their value to some action in the brewer's copper, must depend upon some solution of our own, as must the whole theory of destructibility by the process of boiling. Let us, therefore, proceed to examine the proximate principles again, in their application to this subject.

1. *Gluten* contains nitrogen, which is lighter than atmospheric air; for the air, according to the best philosophy, is thus compounded:

77	parts of	nitrogen, each	·297	of a grain	= 22·87	grains.
22	ditto	oxygen, each	·338	ditto	7·43	do.
1	ditto	carbonic acid	·465	ditto	0·46	do.
100	ditto	atmospheric air	·3076	ditto	30·76	do.

Consequently, this last proximate compound, whenever or however decomposed, must necessarily liberate the nitrogen and suffer it to ascend, and either escape or buoy up the gluten.

2. *Starch*, if any remain unconverted, is only soluble at a temperature a little below boiling heat, but forms with boiling water a kind of jelly, so that boiling prevents its conversion, and it becomes inert and useless, leaving the other elements, and especially those that constitute sugar, (which greedily imbibes oxygen while in an expanded state,) subject to all the ravages of heat from the fire; and to assist in discharging the volatile nitrogen of the gluten, already too fickle in its stability.

3. *Mucilage*. As this is the last constituent in the extract which decomposes under ordinary circumstances, and as it is desirable that it should be the first to ferment rather than the last, its propensity to exist in malt liquors *as mucilage* is encouraged, and its continuance is perpetuated by carbonisation, which is one of the greatest evils of boiling, as far as the department of the mucilage is connected with it.

4. *Albumen* is "adhesive," and will, as has been shewn in Chapter II., coagulate at 52° below the boiling heat; so that boiling destroys, partially if not totally, the vigour and original nature of this great principle.

5. *The phosphates and other salts*, which originally depended on the soil, though not consisting of more than a 400th part of the whole, are nevertheless worthy of consideration, being deliquescent and accommodating. From the known nature of the action of heat upon liquid salts in general, we cannot but see that they are safer

when the liquor is not boiled than when it is. It has been shewn how useful they are, and yet how soon will heat remove them!

Hence the whole chemical investigation shews that much boiling impedes the solution of the starch, discolours the saccharum, and especially if done by means of a furnace, retains the mucilage in its unconverted state, hardens the albumen, and expels the salts, or irrecoverably impoverishes each of these constituents; in short, does every thing that can destroy the ingredient mass, *ex parte* or *in toto,* but nothing to restore animation or to recover flavour. Practically speaking, it tears asunder the integumental amylin and hardens it, and so far the action of heat rudely supersedes the natural operation of the diastase, which would have done its work in the mash-tun by gradual insinuation, had it been kept patiently and at a proper temperature; but this bursting of the sphericles by force proves that some of them have escaped laceration by the diastase when in the mash-tun, or in other words, that its power has been impeded by imprudent haste or improper heat.

The experiments of Payen and Persoz, chemists of high standing, stand already recorded in this work, as do those of other chemists, to whom may be added Thomson, who takes 10 parts of ground malt to 100 of flour, and when he wishes to realise a syrup, he keeps the temperature between 158° and 167° during three hours; but if he works to obtain dextrine, "*with as little sugar as possible,*" he raises his temperature to the boiling point, which in his own words "puts an end to the action of the diastase." This proves what is most important to the brewer, that boiling paralyses the natural powers which protect him.

But soluble starch, being released in the copper, retains its original consistence in defiance of the effects

of heat, until it is subjected to fermentation, because the violence that broke its shell and set it free, was too high for its saccharisation, and would be so, did all other circumstances agree; but they do not, for the action of the diastase, both on the shell and on its contents, is purely chemical in the mash-tun, whereas that of boiling heat on the shell alone is merely mechanical; and the idea, chemically considered as above, that these flakes or flocks consist of the shells of starch, some albumen, and perhaps some other portion of the gluten, is supported by their apparent increase, as boiling, the cause of their production, is continued; and we may add the evidence of their solubility in water, their extraordinary expansibility by heat, their susceptibility of fermentation, their colour, and their concomitant testimony. Their subsequent submission to the vinous fermentation proves that they possess an innate virtue, which they would have dispersed to the surrounding elements if left to pursue their natural course; and that under extreme coercion they hold together, and sturdily defy the power of boiling till they sacrifice their vitality in the resistance which they offer to the tyrannical sway of fire; therefore boiling is injurious, and excessive boiling is irrational.

With respect to dome coppers, one London brewer, of great eminence in his profession, thinks that if worts were boiled, or more properly simmered, *in vacuo*, at 160° or 170°, similarly to the plan followed by sugar refiners, the mode would be preferable to the old system, as a means of preserving the aroma, and securing soundness; but if it could be done at so low a heat, we might thence infer that the whole secret lay in the act of ebullition, well knowing that it could not take place in an ordinary copper under a temperature of 212°; yet the air-pump and dome could be dispensed with, if

nothing more than commotion were necessary; because the heat could easily be kept up at 160° or 170°, and a rouser might be used, which would act within the wort like the flies of a churn, and thus keep the whole mass in motion; but the author is fully persuaded that such an expedient would not be productive of advantage, whether manual, pecuniary, or otherwise; because temperature is the agent, and not motion, except as regards the hop, the latter being the effect, but the former the cause, which is another instance of the error, common among superficial observers, of mistaking the one for the other.

III. Improvement of the Flavour.

In the third place, which becomes a matter of course, boiling destroys the flavour of wort. There has been an object in boiling, and sometimes in long boiling, which has aimed at the reduction of a great length, in order to increase the density of the extract; and on that subject a free opinion has been expressed in Chapter V., page 161; but will any one presume to say that this has not been done at the expense of its flavour, which is its most valuable property? By the new system of extraction by means of the Attemperator, little above half the usual quantity of original liquor is used, so that the worts are made too strong, and require dilution with water, which can be added advantageously at any period; even in the fermenting-tun, which may excite some surprise, and yet the practice is correct. Another objection will perhaps be, that the boiling also blends the whole of the soluble parts of both malt and hop into one homogeneous mass, so that the distinct flavours cannot be discerned: granted that this is done, the previous aroma must, however, be omitted, because it has evaporated! and certain parts have coagulated;

and, with all due submission to those philosophists who uphold such a practice, the patentee of the Hop-convertor, invented as a substitute for that operation, or a greater part of it, begs most positively to assert that the next,—the forthcoming process,—that of fermentation, is a thousand times more powerful in this particular than any boiling, or any other imaginable application of fire.

Worts, when in fermentation, are in constant motion and gentle effervescence, emitting gases in a manner somewhat similar to the mechanical operation by ebullition, and the emission of the steam caused by boiling; but here the analogy ceases, because the other effects produced by the two processes are diametrically opposite; as continued boiling, by the mere expulsion of gas, renders the worts flat; whereas fermentation imbibes one gas while it emits another or two, and is thereby kept lively and healthy, as well as by a partial retention of carbonic acid gas. Boiling, by increasing the density, makes the worts more clammy; but the active heat of fermentation decomposes and re-arranges every vegetable principle, attenuates every particle, and reduces the specific gravity of the mass. In short, the remains of the original properties in fermented worts, are much more intimately blended with those that are newly acquired, than in such as have been boiled, as is evident from the greater difficulty that attends the analysis of the former. The author is not singular in his opinion; for that of Baverstock was published in his "*Hydrometrical Observations*" as early as 1785; and Dr. Shannon, a great advocate for *short boiling*, whose large work on brewing appeared early in the present century, says, at page 235, that the vast injury which the worts sustain by long boiling, may be avoided with convenience by short liquors and stiff mashes, because

there is less to evaporate, or reduce to a standard gravity by boiling down, and consequently that less of the volatile principle of the materials will be dissipated, "to the *annoyance*" of the neighbourhood, and the brewer's loss in stock and fuel. He thought, however, that short boiling required greater rapidity, and that if a wort had boiled *an hour* when "the criterion" appeared, it might then be turned out of the copper in a few minutes; but, be it cautiously spoken, the annoyance in the atmosphere, which some esteem as *deliciousness*, would be less if "the criterion" were done away with, and never attained more. The doctor thought that boiling the wort before the hops were added, was a bad practice; therefore he recommended simmering while the first wort waited for the second. "It is from over-boiling, and under-attenuation," says he, "that strong beers and ales owe their gluey rawness and glutinous fulness, that passes with some for body and strength. In the application of these rules, the abuse of over-boiling is further pointed out."

Not only to England and Ireland, but to Scotland also, has the same kind of opinion and advice extended; for the "Scottish Ale-brewer" informs us, that though various opinions prevail on the subject of boiling, he can safely assert that his countrymen generally boil for shorter periods than the English, varying from an hour to an hour and a half; but that he is no advocate for long boilings, since, if the time exceeds an hour, the coarse flavour of the hop is extracted by it, and the fine aroma, being evanescent, flies away with the vapour, and "*may be sensibly felt*" by those who approach the brewery; which evils, with others that are consequent on boiling too long, he is desirous to prevent; and he considers that the flavour of the ale depends very much on careful attention to these particulars; but, like all

the others, he advocates *some* boiling as a means of extracting the aromatic flavour, and of coagulating the "gluten!" as he calls it, into flakes. One of these objects is now accomplished through the Hop-convertor, and it would be more to the brewer's interest were the other not to be mentioned.

It seems clear, then, for what purpose these advocates have advanced their arguments, while in principle they objected to the practice, which Hayman designates an "erroneous one," and contends that where the hops are put to the first strong wort, without undergoing some preparatory process, the richness of the wort clogs their pores, thereby increasing the difficulty of extraction, and consequently diminishing their preservative quality within the body of the wort; besides which, he considers that if these hops be afterwards put to small wort, its thinness unsheathes their pores, and it is made too bitter. To remedy this loss and inconvenience, he has had recourse to a contrivance of his own, approximating in its character to that of the Hop-convertor, though at a great distance as an invention. "My plan has always been to soak the hops in warm liquor, previous to their addition to the strong-beer wort, in the following manner:—Closely adjoining the mouth of my copper, I had a small back erected, called a steeping-back, into which I put my hops before I turned my second liquor over the goods. As soon as this liquor was heated to about 165 or 170 degrees, I sprinkled my hops well with it, turning them repeatedly, until every particle was thoroughly damped; and I have found this method, from experience, create a saving of one pound in ten, which needs only trial to be confirmed." Here, then, in decrying the boiling system, is a principle advanced, though by no means so searching and efficacious as the plan now pursued.

Levesque also recommends short boiling, and strongly condemns the common practice of bestowing two hours on a first wort, in "dissipating those fine qualities which it was the brewer's intention to preserve, under the idea that the beer will not keep without, which is an error in judgment." He thinks *fifteen minutes* a sufficient time for the interstices of the wort to become transparent enough to betoken the "union or combination" of the particles of the two extracts, the *farinaceous* parts of which he supposes to coagulate into flakes. Thus one imputes that to farina, which another ascribes to gluten, and a third, Wigney, assigns to *mucilage*. Enough to say, that none of them is correct in his estimate, though all repudiate long boiling as a dangerous practice, of which some of them likewise see that the expense is formidable. But here is a writer carrying out the principle of innovation, so far as to endanger the safety of his wort only for a quarter of an hour; but the question is, why endanger it at all? Had he, or any of the authors whose opinions have been cited, had thought and opportunity to apply the steam apparatus, and a correct system of fermentation, the patentee is almost convinced by their language that they would have abolished boiling *in toto*, as a friend in Buckinghamshire has done, who says that he finds the plan of non-boiling so satisfactory, that he has conducted ALL his brewings on that system for many months, in very hot weather as well as cold, and is persuaded that it is a decided improvement. Common modes of conducting the fermentation undoubtedly require common boiling; but there is an *uncommon* mode which may be relied on, and in addition to the saving of one pound in ten, suggested by Mr. Hayman's mode of sprinkling, another and still more important benefit will be found to arise from the use of the Hop-convertor, by a second saving in the wort, equal

to the quantity hitherto consumed in the absorption by the hops in the hop-back, which is generally lost; for, notwithstanding that the hop-press has for many years been introduced to the trade, it is deemed more prudent under the new system to waste what wort they retain, than to use the very nauseous, bitter, and often acid fluid that exudes from the vessels and tendrils, unavoidably crushed by such violent means as the screwing operation.

For the information of persons not in the trade, the author has subjoined part of a table shewing the quantity of wort imbibed by different weights of hops while boiling, and after the usual drainage in the hop-back. The correctness of this table, which was drawn up by the veteran Richardson to accompany his saccharometrical observations, has never been disputed, but, on the contrary, is universally admitted by the trade to be an admirable standard of truth. (See Roberts, p. 102; and Levesque, p. 95, who gives the quantities in quarts instead of barrels, as 10 lbs., 24 quarts; 20 lbs., 48 quarts, &c.) being always half a gallon to the pound or more; and whatever be the quality or strength of the wort last brewed, or last drained through the hops, this certain quantity of wort is imbibed by them, at the rate of a barrel to every 60 lbs. consumed.

Hops used.	Wort imbibed.	Hops used.	Wort imbibed.	Hops used.	Wort imbibed.	Hops used.	Wort imbibed.
lbs.	barrels.	lbs.	barrels.	lbs.	barrels.	lbs.	barrels.
10	0·16	15	0·24	20	0·33	70	1·16
11	0·17	16	0·26	30	0·50	80	1·33
12	0·19	17	0·27	40	0·66	90	1.50
13	0·21	18	0·29	50	0·83	100	1·66
14	0·22	19	0 31	60	1·00	200	3·33

When return worts, or beers of 16 or 18 lbs. gravity *per* barrel, are the last liquors retained, the loss is not

of such great consequence as that sustained by a single brewing of strong ale; but it amounts to something worth saving in the aggregate; and though by the new system the last worts are certainly retained, the loss is considerably less than by the practice sought to be abolished; for under the new mode of treatment, the hops will not retain worts with such tenacity as boiled ones possess over those that are designed for conveyance from the copper to the coolers; but they merely keep the last few barrels that leave the mash-tun, and that consequently consist of the *weakest portion of the whole extract,* and which do not exceed the specific gravity of water: such is the effectiveness of the Hop-convertor; besides the great saving in coppers, coals, and labour, and the greater cleanliness which attends the operation; so that, in fact, *none* of the frightful waste by boiling, as exhibited by brewers and authors, can be sustained where the principles of these inventions are truly carried into practice.

The author, before closing his remarks on boiling, which otherwise might end here, begs to direct the attention of his readers to the pretensions of one advertising quack, who has revived and promulgated a practice where it had become obsolete, or had never before been dreamed of, which is, "*a remedy for refreshing sour beer,*" by which beer that has become too acid for use, should be passed through the grains before they are removed from the mash-tun on a brewing day, and afterwards pumped from the under-back into the copper, there to undergo another boiling, either by itself, or in the ordinary new wort: the effect of such a procedure, be it left to what discretion it may, is too ridiculous for common notice; however, as grains, even in the last saturated state before leaving the mash-tun, contain from 20 to 30 gallons of liquor *per* quarter, according to

the original quality of the malt, of which the most flinty retains the greatest share; so, for the sake of *illustrating* such a practice, we will suppose that 50 barrels of sour beer are turned over 30 quarters of grains, and that just 50 barrels of the supposed beer should be left in the underback, it must be clear, even supposing the 30 quarters of grains retained but 20 barrels of liquor, or about 24 gallons *per* quarter, that the old beer has displaced the original 20 barrels of water, and has taken entire possession of the grains to the same extent, so that this old beer, to $\frac{2}{5}$ths of its extent, is entirely lost to the brewer, his 50 barrels being actually reduced to 30 of beer, and 20 of water. Then the philosophical supposition is, that this studiously prepared mixture is less acid than before, by just $\frac{2}{5}$ths of its quantity; yet such a cure is not sufficiently radical; and in order to dissipate the remaining acid, boiling is calmly and seriously advised; but though it may be true that after this, little acid or none will remain, what then? neither is any *spirit* left; and the result of all this application of labour, fuel, and time, is a weak and worthless liquid, little, if at all, better than exhausted distillers' wash, which, from the similarity of treatment, it aptly resembles! Brewers may now, perhaps, indulge a ray of hope, that when the 10*s.* recipe becomes public, for which Mr. Insleay, of Birmingham, is now soliciting 200 subscribers, as a secret of importance to be known, "John Barleycorn" will not longer be condemned to suffer martyrdom in his old age, in a boiling cauldron.

To conclude: if the general object of boiling be to cripple the natural energy exerted in the ferment of the grain, which is the albuminous gluten, that object is undoubtedly attained in proportion to the time and hardness of the boiling. The juice of the sugar-cane is boiled immediately after its expressure for the same

purpose, and its ferment is skimmed off and decomposed with molasses for rum; because the high temperature of the climate in which it is produced, would cause the juice to ferment before the process of granulation could conveniently take place. Now, the constitution of cane juice is not widely dissimilar, in many respects, to that of malt, except that the latter is much less fermentable than the other; and as long boilings have been found to injure the fermentation, there is reason to believe that the exciting cause is greatly weakened by violence in the copper; but this could not have been the original object of boiling by the brewer, or why add the same quantity, or a greater, of ferment or yeast to the boiled worts again at pitching? Surely it would have been more economical and rational to make the best use of its *inherent* fermenting principle, than to attempt its destruction for the sake of employing an inferior and perhaps acetified substitute for the same purpose.

This chapter must be considered in the main as a theoretical illustration of the subject; yet the facts here noticed will not be lost on the young practical brewer who takes a pride in his profession, can reflect, and is ambitious of excellence. The attention of the general reader is now called to the following explanatory and conclusive remarks, by which it is hoped that the foregoing will be clearly understood.

All admit that the retentive character of the hop flower requires the application of very hot fluids, accompanied by some motion, to remove the *whole* of the bitter property. Every description of bitter remaining in the partly-dissolved hop may be turned to advantage, and so also may the Hop-convertor, in all breweries, by boiling the hops in the last and weakest worts as long as may be required, and at the option of the managing brewer; yet he will allow, if master of his business, that

the qualities of the hop so extracted, ought to be avoided in choice and expensive fresh ales; but few men are willing to acknowledge their own errors, though it was admitted by the most practical and skilful, 60 years ago, that the only motive which a brewer could have for boiling his worts, was that of extracting the necessary virtue and flavour of the hop flower, without the rank bitter of its leaves, stalks, or styles. Though non-boiling will, no doubt, be found advantageous under proper regulations, as soon as the prejudice of old-established custom can wear away, and has been proved to be preferable in many cases named to the author, besides any enumerated herein, yet the system is applicable only where the following circumstances exist, together or separately:—

1. Where the contents of the mash-tun can be heated to any temperature by which the necessary conversion, coagulation, and filtration, can be rendered subservient to the will of the operator.

2. Where the worts can be fermented at or below 52°, as described in Chapter XIV.

With the present (or old) system of extraction and fermentation, a moderate boiling is necessary, especially during the summer season, if only to weaken the decaying energies of the azotised matter, so as to facilitate its separation and ultimate removal; and besides, that which remains in the body of the beer after racking, is, from its crippled state, inimical to further change. Upon this principle we may account for the keeping qualities of beer, in proportion to the drying or carbonisation of the materials, other circumstances being similar, and all extremes avoided.

CHAPTER X.

COOLING.

NATURAL WAY—NECESSITY OF CAUTION—LOCALITY OF UTENSILS—SCOTCH AND ENGLISH DIFFERENCES—OPIATES—BAVARIAN MODE—ANTI-FERMENTS—PITCHING HEATS—EFFECTS OF LOW TEMPERATURE—CAUSES OF PERFECTION—ATMOSPHERE—FOX TAINT AND CREAM—WOODEN COOLERS—METALS AND EARTHS—GALVANISED WORTS—THE FELSPATHIC TILE COOLER.

THE second part or division of the Art of Brewing, is the important process of Fermentation, to which end *Cooling* is preparatory; and much as the beverage depends for flavour and quality upon the first consolidation of the extracts, on the incorporation of the whole of the nutritious and exhilarating properties, and on the rejection of all that is nauseous, hurtful, or otherwise objectionable, the great care of all is the production and preservation of the alcohol, and the retention of those wholesome principles in conjunction with it, commonly called *body*, which give to malt liquor its great character of maintaining strength in man; thereby placing it far above all distilled liquors in the scale of utility, though not of uniform profit, as an article of commerce.

To persons who have considered the subject with any degree of attention, the author scarcely has need to advance more than he has already observed in reference to the difficulties, whether natural or artificial, which beset the brewer in every stage of his progress. Perhaps no branch of manufacture is more uncertain in

the result of its operations, or is less understood in its nature as a means, and especially this most important branch, Fermentation ; for though the first chemists of every age have experimented and written on the subject in common with others, a great part of the practical effects of affinity evolved by it are still enwrapped in an obscurity almost oblivious. To reveal, by means of experience, the mysteries which modern chemistry tends to illustrate, is now the main matter in pursuit ; for extensive as are the improvements that have taken place in almost every branch of our productive skill, from the flimsiest fabric of the cotton loom to the magnificent hardware of the vase and the chandelier, to say nothing of the safety-lamp which protects the life of the miner, upwards to the Bude light which preserves the vision of the senator ; or yet of omnigraphs, electro-magnetic machines, galvanic apparatus, photogenic drawings, electrotypes, calculating automata, atmospheric locomotive propulsion, and fifty things more ; still the critical and sublime art of fermentation, than which nothing can require greater vigilance and care, slumbers on much the same as in the days of our ancestors, the practice and the utensils being, with but few exceptions, intrinsically the same, though ill-adapted to a purpose so very delicate and intricate ; for though dependent on principles purely chemical, the subject has not been thought worthy of that peculiar and popular attention which its extreme nicety demands, in order that its conditions may be well understood, and its best effects duly appreciated. A few choice spirits there are who, to use the words of a friend, may be emulous to "place the art on its proper pedestal, and appropriate to it a niche in the Temple of Science," or who may look steadily to "that great end where the brewer reaps his *golden harvest*, meaning fermentation ;" but such are

thinly spread, and the harvest, be it golden or brazen, is to the cultivator and not to the gleaner. A stimulus, in fact, is wanting; for notwithstanding the progress which science has been making collaterally, it is surprising that the bulk of the men whose interest it is above all others, should not take care to have every particular of the art investigated and perfected, so that they might place the brewery on an equal footing with other scientific establishments, but should be the last to take it in hand; and we shall be the more astonished when we consider the uniformity which is desirable in the production, the respectability and wealth of the parties generally engaged in it, their extensive and everyday practice, the competition which increases among them as mere traders; there being now 2,251 breweries, 57,591 victuallers, and 36,298 beersellers, giving a total of 96,140 licenses in England and Wales, besides 338 breweries and 29,640 victuallers in Scotland and Ireland, or 126,118 in the whole United Kingdom, according to the returns for 1842; and the vast consumption which they produce amounts to about twelve millions of barrels annually. No class of traders are exposed to greater risks in their dealing practice; nor are there any whose profits and losses are consequently so fluctuating.

To attempt a scientific digest of the *modus operandi* of fermentation is an undertaking which few brewers have had the courage to attempt, and perhaps a speculation as to the primary causes is as much as can be expected here, when the extensiveness of the subject and the limits of the field are considered; but it will be necessary to explain the rudiments and effects of the system as at present understood, and to introduce some new views and proofs, in order to convey to the mind of the reader, should he not be a chemical brewer, an

explanation of the reasons which have induced the writer to alter the practice pursued in this country in fermenting ales, and in preparing them for the change which they have therein to undergo; because, where the necessary preliminary of cooling has engendered the seeds of damage, the most careful fermentation cannot restore the beverage to its pristine goodness.

Cooling should take place with the greatest caution and care, and consequently no coolers should be used except such as are best calculated to assist in the attemperation, and to maintain the proper decreasing temperature without fluctuation, and without suffering any absorption which may injure the quality or taste of the wort before the constituents commence the work of decomposition which is incidental to their reorganisation. Not only should the cooling utensils be placed where the surrounding medium gently aids the gradual and quick diminution of the acquired heat, but their position should also favour the transit of the worts, and if possible, without pumping; and should be an intermediate stage of locality in the road from the Hop-convertor to that place of uniform temperature to which hereafter they ought to be consigned for the work of fermentation.

The principal champion of the Scotch method observes, that it is usual for the English to set their worts as high as 75°, or even 80°, "according to some practical writers;" but the Scotchmen seldom or never exceed 58°, but sometimes cool down to as low as 44°; and he takes the average of the high range at 65°, and that of the low at 50°; but in a cool atmosphere of 42°, he supposes them to average about 53°. And why this variance? His answer is, that different heats require corresponding differences in the time required to complete the fermenting process, and that while in Scot-

land the gyle is not hurried through, but may remain 21 days, the English think it slow if it remain 6 days. The English, however, are not ALL as he describes them, and the author for one, nor is it fit that they should. One brewer in the South of England recommends pitching a wort of 45 lbs. gravity *per* barrel at 45°, "if the gyle tuns are in the ground," and this is the greatest strength which he can recommend. He would pitch a 6 lbs. wort of small beer at the same temperature, only altering the quantity of the yeast, putting 3¾ lbs. to the ale wort, and only ½ lb. to the beer. He would never exceed 47½° under any circumstances, and would then put 3·625 lbs. or 3 lbs. 10 oz. of yeast, which he would allow to ferment till his gyle rose 22½° or to 70° for his cleansing point. But neither the practice of the one nor of the other, in their own particular breweries, can be any criterion for the guidance of others, since the *water* alone, in many places, would baffle both in attempting to work their principles into practice, and neither the heat, the yeast, or the time, would correspond in many breweries.

Ales pitched at 80° or 90°, as attributed by the Scotchman to English brewers in general, are of this kind: pseudo-brewers have recourse to the practice, that the produce may attain early brightness when carefully attended to; but it is never *sound;* and its opiate and stupefying influence is its chief recommendation amongst its accustomed imbibers, which characteristic is exceedingly obnoxious and injurious to strangers, whom it enervates in a manner similar to opium.

The Englishman above noticed, evidently advocates the best principle which distinguishes a *rapid* system of fermentation; and in carrying that principle into operation, his time is regulated according to his means. Very different from this is the practice of the Bavarians,

the deliciousness and beauty of whose beer has been noticed in Chapter VIII., p. 249. The Regen Circle, or Vale of the Danube, in the neighbourhood of Ratisbon, near the borders of the great woodland forest of Bohemia, is the district most particularly famed for this unparalleled cordial, and there the wort, as we are informed by Liebig, and after him by Ure in his new Supplement, "after being treated with hops in the usual manner," is put to ferment in very wide flat vessels, having thus a large surface exposed to the air, at a temperature from 45° to 50°, and in this state the fermentation is continued from three to six weeks; Ure says three to four, and that it is placed in "cool *cellars*," but Liebig calls the fermenting rooms "*chambers*." The fact is, that Ratisbon or Regensberg, and with it the plain of the Danube, north and south, from Ingoldstadt to Donaustauf, as celebrated for its ale as the more westerly circle is for the growth of the hops which assist in its production, is situated in the form of a large natural cooler, being so well sheltered by its elevations northward and collaterally, from the frigidity of winter, and by its absorbed and flowing waters and southern screen, the Alps, from the aridity of summer, that it bears out all the characteristic features of such a climate as is physically described in Bell's Geography; allowing that gentle fermentation to prevail which the French cannot effect above ground, and which, in our domestic economy, our householders produce in their cellars, when aware that the atmosphere will overcome all their efforts in an exposed situation. Thus, in fact, the professor and his tyro account for the fact that English, French, and most of the German beers will become vinegar when the air begins to act on them; but that Bavarian will keep through any length of time without

acetifying or undergoing any change. The rest relates to Fermentation, and will be found explained in Chapter XIII.

Liebig again asserts, and no doubt his authority is good, that "the great influence which a rational management of fermentation exercises over the quality of beer, is well known in several of the German states;" and he instances the grand duchy of Hesse, where a large premium is offered for the production of beer brewed upon the Bavarian principle, the prize to be awarded to any competitor who can prove that his beer has lain six months in the store-vats without becoming acid. Why cannot this be done in England, the queen of barleyed nations? That sites possessing eligibility, with advantages even superior to those thus generally described as existing in Bavaria, can be found in every part of Great Britain, by a judicious availment of which, the brewer's worts may, by proper cooling and a peculiar kind of fermentation, be converted into an almost imperishable and altogether delicious beverage, abundant evidence shall hereafter attest; and this eligibility, with the practicability of the principles to the fullest extent, shall be incontrovertibly proved; but, first, a necessary preliminary must be observed.

The difficulty of conducting the brewery in warm weather has been uniformly felt, and is exactly in case here. The Scotch and American brewers forego brewing ales during the hottest month or two in the year. Roberts tells us that till lately the *fox* was hardly known in Scotland, because the brewers of strong ale brewed only in the colder months, their coppers lying silent from May to October (which, by the by, is a long while to be lazy, or to punish the poor trout either). But, he avers, some of those who brewed *inferior* ales,

ventured to brew throughout the summer, and ran the risk of this insidious disease, which therefore sometimes crept into their worts.

A few of the London brewers also relax their energies, and avail themselves of the dog-days for the repair of utensils and the like. To a warm atmosphere and neglect of the vessel may be ascribed the disease called the *foul* in wooden casks, &c. Hence the necessity of discontinuing vessels of wood in the various processes, as far as possible, and of devising some plan which may obviate the inconvenience of suspending business throughout the best months of the year.

WOODEN COOLERS. It may now be proper to point out the inconvenience always attendant on keeping in order that erroneously constructed utensil, the wooden cooler, or "very wide flat vessel," of the British brewery. The ruinous consequences of its frail nature, its extreme porosity, and its liability to contraction, render the partial but constant application and removal of lime and water indispensable, by which its decay is assisted rather than arrested. It is generally admitted that the offensive flavour arising from the foxing of the worts, and its evil influence on the vinous fermentation, can always be detected but never remedied; and besides the injury which the ale sustains by being in contact with a substance so perishable and ever-decaying as a vegetable cooler, ulterior consequences must not be forgotten, such as loss of reputation, and desertion by the best customers, which are matters of paramount importance.

The best cure for a wooden cooler is to burn it, and to substitute another of less precarious material, which may be the means of preventing creaming by spontaneous fermentation, caused chiefly by the reception of too much oxygen; a principle which must be denounced as a bane; for although spontaneous fermentation may

succeed at a mild and constant temperature, practice tells us, and the author knows from direct experiment, that it is preferable to add a gradual supply of ferment, to feed according to the wants of the declining matter; and it is far better to withhold the supply of air, than to overcharge with it; because the surplus attacks the alcohol, and the consequence is, that either the acetous fermentation is encouraged and excited, or that, at least, the vinous is suspended or diverted; and the whole or some of these disasters occur in proportion to the artificial surcharge: Dr. Henry discovered this in one instance, by his failure when infusing atmospheric air by Nooth's machine, in preference to barm.

One thing that tends, to a very considerable extent, to hasten the decay of wooden coolers, and is perhaps the principal original cause, is the latitudinal friction arising from the alternate expansion and contraction of the planks, upon the reception and impartation of heat and moisture, in which respect they more or less resemble sponge, according to their compactness, by which reciprocation of toward and untoward motion, the fibres are made alternately to recede from each other, and again to approach; thus pulverising their own albumen, and grinding away the more solid substance; increasing also, by such attrition and other motion, the decomposition of all other matters absorbed by the pores, or within the sphere of their action.

The albumen of timber lies between the fibres, and is the first to loosen and perish; that nearest the outside either floats out of its cell, or exudes therefrom, and is swept away by the cleansing broom; the breach thus formed soon becomes deeper and wider, and ultimately affords easy ingress to the vegetable moisture, until the whole plank is saturated with principles that decay with greater rapidity than the displaced albumen itself; this

ligneous substance in its turn decomposes, recedes, and makes way for the reception of new matter; so that the pores of the wood are so many fermenting vessels for every stage, from the vinous to the putrefactive. These places are never full, though always filling with the solid matter of the wort, which, through this continuous but varying decomposition, forms an accumulation of starchy, glutinous, lupuline, and albuminous admixture, ever dying, but never extinct, thus rendering the timber more spongy and leaky, until the fibre, which began to perish from contagion at the onset, gives way; and the general consumption increases daily, until the employment of the back-maker becomes inevitable. During this work of destruction, the worts are absorbed and wasted, and become so permanently impregnated with acidity, that they not only irrecoverably lose their flavour, but a poison is imparted to them by this seemingly spontaneous, though unintentionally excited, vino-acetous or acetous fermentation of the worts, which daily increases.

Again:—the contraction and expansion of the boards creates a species of pump; for when the timber imbibes heat, as it does when the hot wort is on, the pores expand, a partial vacuum is formed, and whatever is in contact, as wort necessarily is, instantly enters by virtue of atmospheric pressure: the wort, however, directly begins to impart its caloric to the surrounding media, and as this cooling proceeds, the timber contracts, the fibres assume a more compact position, the pores close, some air, ferment, &c., issue from them, and the foxing of the worts is natural and inevitable; for

"One touch of nature makes the whole world kin."

As shewn in a former chapter of this work, Levesque has noticed, that grains by standing "strike an acid

into the wood" of the mash-tun, and cause a fermentation within it; and an allusion has been made (p. 200) to the loss of property experienced in a notable establishment; and if wood is thus liable to become acid in a vessel which is usually kept at a high temperature, how much greater must be the tendency to imbibe a pernicious virus in a cooler which is subject to the variations of temperature, often many times in every week, and which, of all utensils in the brewery, contains the greatest surface to the least solidity; and if such is the effect upon solid matter, what must it be upon the liquid contained in the cooler, at a time when, by alternate changes of temperature, its particles are in the most unquiescent state of susceptibility? Indeed, in all brewing vessels constructed of wood, liable as they are to excessive changes of heat and cold, siccity and moisture, a proneness to acidity must ever be prevalent.

Mash-tuns, fermenting-vessels, and store-vats, are generally made of oak, though coolers are almost universally constructed of Dantzic deal, or of pine, which, though of more hardy growth than oak, is nevertheless more porous and perishable; and we may here name a fact that cannot have escaped the notice of all persons engaged in brewing establishments, which is, that all wooden vessels that are treated with the hottest liquor, are the most durable: such, for instance, as the hop-back, which receives the wort in nearly a boiling state; and next to it, the cooler which is built the nearest, which lasts twice as long as that which is farthest from the hop-back, because the liquor which flows over this last, is cooled in its transit from the copper and intermediate vessels. The greater preservation of certain utensils may be owing to some partial consolidation of the albumen of the wood, or to the preservation of its fibre, or both, by the great heat of the liquors, much in

the same manner as the effect of the bichloride of mercury in Kyan's patent, or the sulphate of copper or iron, the pure chloride of sodium, the acetate of lead, &c., used by others. Another durable vessel in the brewery, and which is generally made of oak, except that in London some squares are of red deal, and some few tinned copper rounds exist, is the fermenting-tun, notwithstanding that the heat of the contents of these vessels seldom exceeds 80°; but this is attributable to the spirit or alcohol of the fermenting wort, acting in a similar manner to that performed by heat on the other vessels described above. The great and novel object of the present apparatus is the arrangement of the fermenting liquors, so as to encourage a perfect and equable fermentation of that principle which alone produces spirit and odour or flavour, which is more certainly done by avoiding contamination; and what can be more detrimental than the solution of taints that emanate from the vessels of wood? It must be clear, therefore, that the farther beer is kept from wood, the better it keeps.

These objections to wood in the construction of coolers, will also apply to it in a minor degree when used for gyle-tuns, barrels, &c., and especially those vessels in which the fermentation has to be conducted, or which have been otherwise subjected to the influence of change in the temperature of the atmosphere, notwithstanding all the effects of scalding, which, like a quack medicine, only alleviates present suffering, to increase the future virulence of the malady.

One great requisite of a cooler is, that it shall be a good conductor of caloric, not only by receiving it from the heated liquid, but by its speedy conveyance elsewhere; but it happens that the heaviest and least porous

woods are the worst conductors, as the following extracts from Meyer's tables will shew:—

Wood, compared with water.	Conducting power.	Specific gravity.	Wood, compared with water.	Conducting power.	Specific gravity.
Water	10·	1000	Oak	32·1	668
Ebony	21·7	1054	Ash	30·8	631
Apple	27·4	639	Pine......	39·	408
Beech	32·6	692	Scotch Fir..	38·6	408

But these specific gravities differ a little from those given by Ure, though the ratios are much the same.

METALLIC COOLERS.—Richardson's experiments led him to conceive that the decrements of temperature in a given time, might be considered to mark the difference of their conducting powers, which he found to be in these proportions:—Lead 25, tin 17, iron 11, copper 10, and brass 10, which two last also contain the greatest *retentive* power; but he eventually concluded that the increments and decrements of the bodies on which he experimented, were not in the inverse ratio of their density, their hardness, their cohesion, or any ratio compounded of them. That they bear no proportion to their specific gravity, is clear on comparing them with Ure's tables, which give lead specific gravity 11,350, tin 7,291, cast iron 7,248, copper 8,900, and brass 8,000.

Another great objection to metallic coolers, especially to zinc and lead, is, that though smooth and clean at first, they soon become wrinkled and rough, and present ridges, dents, blisters, and furrows, all caused by their repeated expansion and contraction; for when these metals are exposed to hot liquors from 150° to 200° or so, their contraction at cooling is never equal to their former expansion, and they gradually lose their contracting powers; and the longer they are exposed, the

higher those hillocks become, until at last the expansive and contractive power is altogether lost, the surface is rendered uneven, and the wear on the projections makes them thin, till they ultimately crack in those thin places, and the unevenness is again increased by the repairing solder; and besides, such metals are backed by a non-conducting substance, so that they imbibe the heat only to return it to the wort again, as it cools by evaporation. The character of all these metals is, that they are "very good conductors of heat and electricity;" so that they are great absorbents and famous agitators, but bad coolers. Iron might perhaps answer better, had it not a strong predisposition to rust; though we must admit that great progress has of late years been made in the purification of that metal, through the agency of smelting furnaces. For instance, a metropolitan brewer, who erected some iron fermenting squares in 1833, was obliged to take them down again; and yet the author, in walking through one of the large London breweries in 1842, was particularly struck with the elegance of a large range of new iron coolers. Iron, however, has a great affinity for oxygen, and is a conductor of electricity in the highest degree, the pure metal being no where found in its raw state, except in masses supposed to be of meteoric origin. In short, making all allowances for the progress of art, the general intrinsic character of metals at large, militates against them as utensils to be employed in a brewery; for their relation to oxygen is accounted the most interesting quality, which is general to all metals; but the brewer cannot afford those contaminations to which his worts must become subject when in contact with them, and particularly in fermenting vessels.

It may perhaps be thought necessary to observe, that

worts cooled gradually by the winds are suffered to lie from *seven* to *nine* hours, according to the usual practice of the old school, except in very cold weather, and in that time they imbibe a vast quantity of atmospheric air in an undecomposed state, from which they abstract oxygen as the after-process goes on. Men thought formerly that a greater duration of time would cause a greater *expulsion* of an unknown something, which they conceived to be inimical, not being aware that the reverse doctrine of absorption was impregnating the wort with evil all the while. It is also probable that in most cases when rapid cooling began to be practised by artificial means, the operators pitched at the same low temperature as before, thereby causing disappointment through a slow and languid fermentation, especially in strong worts, after the attenuation was two-thirds or three-fourths completed, instead of attributing it to the absence of the theretofore wonted quantity of air, and without seeing the necessity of a higher pitching heat, or a little more patience, under the altered circumstances; while another class of objectors ascribed their imperfect fermentations to some galvanic action of the metals of which the cooling instrument was made. This suspicion may not be unfounded, particularly where sulphuric or muriatic acids abound in the water, and that most injurious of all metals, zinc, forms a part of the cooling machine. Wort will become galvanised by coming in contact, when hot, with a combination of improper metals, and be so susceptible of fermentation or *decay*, as to continue that process as long as any fermentable matter remains in it, let the temperature be reduced and maintained even as low as 54°, when a low species of acidity ensues, and perfect brightness is altogether out of the question. It may be proper likewise

to observe, that this galvanic effect is more certain and influential when the wort is above 100° than when below it.

EARTHEN COOLERS.—Earths are said to be bad conductors; but a thin slab of marble will heat as soon as an equally thin plate of iron, and porcelain will maintain a much greater heat than gold. Pour equal quantities of hot water into equal and similar vessels of wood, metal, and earthenware, and that will cool the quickest which is poured into the earthen vessel. Saucers of porcelain are used for the cooling of tea; but plates of tinned iron, or other metallic substances, are used for dish-covers, and are found more serviceable than earthenware to preserve the heat in provisions carried to a distance. Soups, which require much longer time to cool than water, are often poured into basins of delft, and placed in cold water to expedite the process of cooling; while, on the contrary, hot water is put into metallic dishes, which retain the heat, to preserve the warmth, and prevent the gelidising of gravies in winter, when earthenware plates cool them too rapidly, though this is the effect of radiation more than of conduction. In the article of coolers, on the same principle, we shall find that the nearer we approach to the materials of cold mountain rock, and colder mountain clay, the more effectually will our purpose be fulfilled. It may not be amiss here also to notice, that if worts be set to ferment without yeast, in wooden and glass vessels at the same time, those in the wood will invariably be found to commence the operation in half the time that will be sufficient for the contents of the glass vessel to do the same thing. This the author has often proved by direct experiment; and he cannot account for it, except on the principle that the saccharine liquor displaces the air contained in the pores.

Something beyond specific gravity is required as a test for stone. For instance, Yorkshire stone weighs some 2500, or considerably within 400 of Valencia slate, which is 2865, as 150 feet, at an inch thick, weigh a ton; but in some experiments made by the Honourable Board of Ordnance on slabs of these two substances, cut of equal size, the former broke with a weight of 302 lbs., when the latter required 1285 lbs. to break it. In consequence of its convenience, and of the facility with which it acts as a cooling medium, the author has had slate strongly recommended to him as a material peculiarly adapted to the brewer's purpose in constructing coolers upon a new plant, or in altering an old one by the removal of the wood, and has introduced the substance upon a large scale; but experience has convinced him that, however smooth, straight, and regular, it may be brought to be when put into the hands of the polisher, he finds that the best will expand so much when the hot worts are put upon it, that on its cooling and contraction, which do not keep equal pace with each other, it cracks, and a sacrifice is the consequence.

The most durable, and at the same time the neatest, composition yet discovered, or likely to be, is the Felspathic Tile, for the manufacture of which, chiefly from felspar, a patent is held by Mr. R. Prosser, C. E., of Birmingham. It is unnecessary to say that felspar is one of the constituents of granite and other dense rocks, and is, with the exception of quartz, the most abundant species of stone that exists. Mr. Prosser says, in his specification, that his materials "are brought to a state of fusion in the oven," are "superior to Wedgwood's ware," and that the specific gravity of his tile is in a great measure dependent on the "degree of heat employed in the baking" of it. Specimens, however, of this anhydrous and compact composition have been

weighed, and found to coincide with the fine porcelain brought from Sèvres, its specific gravity being about 2145. What the degree of heat is on which he depends, can only be guessed at, when we are told that it is unapproachable by any metre at present known, and that from the manner in which its particles are jammed together, it is more dense than the pyrometrical rod, and is less liable to fracture than the toughest porcelain from Sèvres or China, though in specific gravity more than 200 below the latter, which is sometimes as high as 2384. The quantity of felspar contained within the tile, gives it an internal vitreous appearance, and yet resembling unctuosity, which splendour is entirely attributable to its compactness: in durability, therefore, it is at present incomparable with anything known as a clayey production, whether fire-brick, porcelain, or other admixture. 32,277° F., the highest heat known, will not affect it, though the best Chinese ware softens at 21,357° F., cast-iron is thoroughly melted at 20,560°, common stone potters' ware is baked at 14,340°, and delft at 6,407° F., which is 117° higher than the melting point of gold. Such astonishing powers as these must at once give the reader some idea of the adamantine substantiality of Prosser's Patent Tile.

This tile is made without water, of a peculiarly dry and finely-pulverised composition, resembling flour, the atoms of which are brought to adhere, and are shapen into definite form in moulds, by immense hydraulic pressure, by means of Bramah's apparatus, so that during vitrification, no pores or passages can be formed by the escape of any steam or vapour. This, then, is the sum and substance of that wonderful improvement upon "the old or *slip* process of pottery and brick-making." The first object of the inventor was to manufacture, as he still does, buttons called "agate," rings, and knobs,

and he subsequently produced the tile. Prosser's tile, as supplied to the author through a commercial treaty, is about $\frac{5}{8}$ of an inch thick, and of a dusky white hue, but may be obtained of various colours and tints, as the beautiful tessellated floor at Messrs. Wyatt and Parker's, near Blackfriar's Bridge, London, a similar one at the Old Library in Birmingham, and some others, will conveniently testify; and although divested of everything like crystal in its composition, and assuming more the character of a lava, it is semi-transparent, and in external appearance like polished marble, but as far superior to it in reality, as marble is to chalk.

The Felspathic Tile Cooler.

In the employment of Prosser's tile as a substitute for wood or metal in the construction of coolers, we must bear in mind, that being of a composition chiefly silicious and felspathic, it is insipid, and consequently cannot by possibility impart a taint to the wort; and so impermeable is it, that neither Nankin porcelain, nor any other substance now known, is so close in its texture. The tiles may be moulded either in trigons, squares, or hexagons; and they can be so finely and accurately cast, that the sides and angles shall exactly coincide; but if they should not precisely fit, through any uneven shrinkage in the oven or otherwise, the moulds being made with sides precisely even, they may be ground to dispose of any unevenness they may have received; and the author recommends that they be cemented when laid down edge to edge, by a peculiar cement mentioned for another purpose in Chapter XIII. Thus we have a beautiful, smooth, level, and clean surface, and so firm, that nothing short of the most extraordinary pressure can affect it. The sides must be bolted down to the joists in the usual way; and the flanges of

all taps, valves, and plug-holes, must be cast of the size and form of a tile, and fitted and fastened in the place of such. Any of the patterns may be enlarged, or additional pieces may be cast, to fill up any spaces that would otherwise appear in completing the edges, especially where the hexagon is selected.

These, then, are some of the principal reasons why the author prefers the Felspathic Tile Cooler to any other; for, after all considerations, it appears superior to any other substance yet devised for the brewer's use, whether its durability, its impenetrability, its cleanliness, its inflexibility, or its eventual cheapness, be considered; and its gradual and certain effect may be relied on.

CHAPTER XI.

REFRIGERATION.

THE BOILING POINT—THEOREMS—BRITISH TEMPERATURE—THERMOMETRIC SCALES—REMARKS ON CLIMATE—FANS AND PIPES—REQUISITE PROPERTIES—WIGNEY—NOTES—MASTERMAN'S APPARATUS.

Having now endeavoured to shew the best mode of cooling wort as far as the natural process goes, the next consideration for the brewer is to find the best access that can be had to artificial assistance where the natural means fail, which, in a country like the British islands, affected by great changes of temperature, will frequently happen, and sometimes when least expected.

A gradual and steady reduction of temperature in the worts while upon the coolers, as the practice has been conducted, has always been advisable when it could be done within the limits of security, or in about *four* hours; but after this period, more speedy means of refrigeration have usually been sought. The majority of brewers now advocate rapid cooling, and they that have refrigerators use them directly after the worts reach the coolers, though when these instruments were first introduced, several abandoned them, from an opinion that they produced mischief.

The object of many brewers is, to retain the worts simply as they are cooled by nature, deferring the use of a refrigerating machine till the issuing vapour has begun to disappear above them, notwithstanding that

this subsidence is regulated more by the state of the atmosphere than by the heat of the worts, so that the criterion is good only in warm weather. It is then seldom visible after the extract has cooled down to 95°, whereas at other times, and especially in the winter season, when refrigerators are not needed, it is perceptible 20° or 30° lower; and hence no fixed rule can be introduced to regulate a temperature indicated by an appearance at once so uncertain and deceptive. It would be much safer to use the refrigerator according to sound thermometrical rules, and to introduce it at a certain statutary degree of heat. Where plenty of spring water can be had, the use of a long range of wide coolers may be economised; but where this essential is scarce, one cooler at least is necessary to assist in the economy of water. On the other hand, nearly all the modern breweries erected by skilful men, are provided with steam pipes to warm the tun-rooms in winter, and their fermenting vessels are lined with tinned copper tubing, supported on brackets, at 12 or 18 inches from the sides, through which pipes they pass hot or cold water at pleasure, which contrivance is most valuable in winter, though it still leaves them at a loss in summer, these pipes being generally insufficiently effective, particularly in large establishments, to reduce the heat in due time: with all his advantages, then, the brewer who cools above ground, can never compete with the subterrane artist, because of the hot air absorbed by the worts of the former in the summer brewings.

A great deal, therefore, depends upon the state of the atmosphere, and its consequent pressure, which affects even the boiling point. "The grand secret of the Munich brewers," says Dr. Ure, "is to conduct the fermentation of the wort at too low a temperature to permit of the

acetification of the alcohol;" and it happens there, as in England, that "it is only in March and October that the good store beer is begun to be made in Bavaria." In Griffith's lecture, published at page 30 of the "Forceps," he observes, that though 212° by Fahrenheit is considered to be the boiling point of water, other circumstances must be considered in connection with it; for at Geneva, which is 1200 feet above the level of the sea, and where the atmospheric pressure is accordingly less, it becomes ebullient at 209°; and at Quito, 10,000 above the sea, it will boil at 194°; and if a vessel of water of 178° temperature be placed under the receiver of an air-pump, and the receiver be immediately exhausted, that water will then boil; the pressure at which this would take place, as indicated by the barometer, being equal to half the ordinary weight of the air, or 7½ lbs. to the square inch. Munich, the capital of Bavaria, stands upon a plain 1920 feet above the level of the sea, and consequently water will there boil at about 207°, the diminution being about one degree in each 400 feet of elevation in the lower altitudes, and one in 600 on rising higher; and if such is the variation in boiling heat, such like variation will likewise influence liquids that are heated only in part.

One of our English writers, like the Bavarians, depends more upon October brewings for future quality than upon any other, because he says, that as the cold then gradually comes on, a too rapid fermentation is thereby prevented, which enables the attenuated beer better to withstand the heat of the following summer; but this rule cannot apply to March brewings, because the weather is then becoming warmer. The same author, who recommends that all brewings intended for keeping, should be made before the close of the year, thinks that

beers for present use may be brewed at all other seasons except in June, July, and August; but he is wrong in this exception, and a good refrigerator will soon widen his error. This old-established but fallacious notion will explode on reasoning over the following facts, deduced from the state of the thermometer kept at the Royal Military College at Sandhurst, in latitude 51° 20′, and which were expressly computed for this work from the Gentleman's Diary for 1812 to 1836, inclusively.

1. Some of the days in February, 1816, were only $\frac{1}{7}$th of the mean temperature of 1819, and not so high a fraction of that of 1818.

2. In 1821, the mean temperature of October was higher than that of June by 4°; and the thermometer was 12° lower in the summer than in the winter month, and on three of its days by 25°; also the 15th of November was 20° hotter than the longest day.

3. The year 1817 presents a contrast to 1821, inasmuch as the thermometer sank in October as low as 35°; whereas in June it was up at 72°, being an excess more than double.

4. The 12th of October, 1819, was hotter than the first of the corresponding month of 1817 by 43°, being 8° above double; and October, 1818, was 33° above the same October *minimum* of 1817, and 34° above that of 1829. The 1st of October, 1831, was hotter than the 8th in 1829 by 28°, and 18° hotter than the 7th of June; and the 20th of October, 1829, was 20° higher than the 8th of the same month. In 1822, the last day of October was 10° higher than the last day of June; but in October, 1831, the average temperature for two whole days was 6° below the freezing point.

5. In July and August, 1835, there were forty-four days in which the temperature varied between 60° and 71°, being an average of 30° above the latter end of

October; but in 1831, five of the October days were hotter by 10° than the 7th of July.

6. The 15th of January, 1818, and several days in January, 1819, though 46° higher than the 9th of February, 1816, were not so hot as the 12th of October, 1819, by 24°; which day averaged nearly ten times the positive heat of the said 9th of February.

7. The heat in 1818 and 1820 was greater by about 20° than in any part of the years 1813, 15, 27, 28, 29, 33, or 35; and the heat on the 9th of May, 1819, exceeded that of any part of 1813, 15, 16, 17, 27, 28, 29, 30, 31, 33, or 35; and the preceding day, May 8th, was colder than the 9th, but was equal to the highest temperature in 1817 or 31, and these were higher than the other years here named.

8. The 18th of September, 1822, was hotter than any day in the above-named 11 years, or in 1812, 14, 23, 26, 34, or 36; being 79°, which none of those years ever reached.

9. October 8, 1829, came within 2°, and October, 1828, within 3° of the freezing point; in 1836, the 29th of October was 2° below the point, and the 13th and 31st were 6° below freezing; but in 1830, the anniversary of the battle of Trafalgar, (Oct. 21st,) was hotter than that of Waterloo (June 18th) by 9°, though on the whole, June was warmer than October by a mean rate of 6°.

10. Lastly, the heat in this country is not so high in some summers as in others by 20°, nor so low in some winters as in others by 30°.

The subjoined remarkable observations were made by the author on his own thermometers at the Nine Elms Brewery, near London, in June, 1842 and 1843, and very clearly shew the precariousness of seasons in England; the situations of the two instruments and the times of observation being the same:

Year.	June 12.		June 13.	
	Sun.	Shade.	Sun.	Shade.
1842 1843	120½° 82½°	84° 59°	110° 56°	79° 53°
Difference . .	38°	25°	54°	26°

The following is more recent and still more remarkable: on the morning of the longest day of 1844, many ponds of water in the eastern parts of England were covered with ice; but on the morning of the shortest day, the thermometer stood at 50°, or at least 28° higher.

If these variations are not sufficient to perplex any man who is obliged to work in the middle of them, he must have a remarkably comprehensive understanding; but to complain of them is not to remove the cause of complaint, nor yet to remedy the evil effects produced; it may be needful to remind the reader, in reference to these heats, and to all others herein named, unless something is specified to the contrary, that they are all taken according to Fahrenheit's scale; and it may be useful to some that a few words be said upon the principles adopted by others when put in comparison with this standard.

THERMOMETRY. For the information, therefore, of persons unacquainted with the history of the Thermometer, it is necessary to prevent any mistakes in the application of instruments differently graduated. The invention, or rather the improvement made on former instruments, by Daniel Gabriel Fahrenheit, a philosopher from Dantzic, resident at Amsterdam, is generally used in Holland, Britain, and North America; that of Reaumur, or Roëmer, another celebrated philosopher of Dantzic, before Fahrenheit's time, was the only one used in

France prior to the Revolution, and is still employed in Spain and other southern European nations; but the French under Buonaparte adopted the scale introduced by Celsius, professor of philosophy at Upsal, in Sweden, called the *centigrade* regulation, which is now general in France, the French dependencies, and most of the countries of middle and northern Europe. Their difference is, that Fahrenheit fixed his *zero* or *nothing* at the most frigid point which had been observed in Iceland, being 32° below the *zero* of Amontons, adopted by Reaumur, which is the point of temperature where water begins to freeze, or above which ice melts, which is also the *zero* of Celsius; but 4° on Fahrenheit's scale are equal to 9° on Reaumur's, and 5° of Fahrenheit's to 9° of the centigrade; so that for the conversion or reconversion of Fahrenheit, or the English thermometer, to or from either of the others, these theorems must be used:

$$F=\frac{9C}{5}+32=\frac{9R}{4}+32\text{; and conversely, }C=\frac{5\,(F-32)}{9}\text{, and }R=\frac{4\,(F-32)}{9}\text{;}$$

and hence the boiling point of water, which is 180° above the freezing point, according to Fahrenheit, is at 100° of the centigrade, whence its name, and at 80° on Reaumur's scale. This is the reason why English authors do not commonly speak of *the thermometer* in their productions, but of F., or Fahrenheit's scale, as the species of thermometric index which they employ.

The temperature of our fermentations has hitherto been either above or below that of the air, which varies as much as 60° or 80° F. within the course of a year, therefore such workings, even where artificial means are employed, are affected more or less by the changes that have been described, and their productions vary in flavour and virtue, as much according to the changeable gradations of the external influence, as to the internal

constitution of the worts themselves. Hence, by the common hurrying and uncertain process of fermenting malt liquors, the heat is seldom so low as 58°, and often ranges to 80°, while at the same time the atmospheric temperature may decrease from 80° to 50°, or perhaps from 50° to 20°, so uncertain are the changes of weather! From these excessive variations, for which no efficient provision has been made, and from the coercive force exerted over the worts to prevent the consequences of a diminution of temperature, but which sometimes has the opposite effect when a sudden increase of heat unexpectedly takes place in the atmosphere, arise many of those hyperbolical vicissitudes to which the worts in their fermentation are liable, and which they assuredly suffer, to the great destruction of the alcoholic principle; for it often happens that when the process is over, a large quantity of gluten and gum remain undissolved in the ale. Liebig tells us that free oxygen and gluten are the *conditions* on which alcohol becomes acetic acid, because they determine its eremacausis; but that the capability of exerting their influence does not obtain at low temperatures; hence, then, the necessity of artificial cooling where a fixed temperature is requisite, and the natural course fails through conflicting causes.

Dr. Shaw's view of decomposition, which is beautifully philosophical, will very aptly apply here: "The intention or tendency of nature is to proceed from the very beginning of vinous fermentation directly in one continued series to putrefaction, and thence again to a new generation; which appears to be the grand circle wherein all natural things are moved, and all the physical or rather chemical phenomena of the globe are produced." The brewer does not wish, however, to avail himself of this whole circle of change, but to

secure the advantages of the first ascendant quadrant, and then to allay the decremental motion in his fluids at a certain *punctum*, or highest beneficial attainment, before the second sets in, by which means he hopes to preserve his alcohol and a portion of his sweet, which properties, if duly secured by a process as nearly allied to nature as possible, furnish spirituosity, flavour, and briskness; for if he would act as a physician, he must understand the kind and cause of the disease, lest he should mistake the character of the balsam which he intends to apply. Is it the Bavarian, or is it his atmosphere, that makes him more expert than we? The question is one that needs solution.

Ratisbon stands in latitude 49° 2′ N., and in longitude 12° 5′ E. from London; so that, in point of geographical temperature, as connected with its distance from the equator, it cannot differ much from London, the latitude of which is 51° 31′ N.; but Munich presents a contrast to this, though situate in latitude 48° 55′ N., or only 7′ nearer the equator, being much elevated, as we have seen, and is nearer to the large lakes and northern declivities of the Alps, and is therefore subject to greater changes of temperature. Hence, notwithstanding the encomia bestowed on the Munichians by Ure, he confesses thus: "In my several journeys into Germany, I have met with much spurious or ill-made Bavarian beer. The best contains, when brought to England, a little acid, but no perceptible gluten on the addition of ammonia in excess." And moreover, "the brewers of Hessia and Prussia, who wished to *make* Bavarian beer, found it more to their interest to send for the article from *Wurtzburg* or *Bamberg* in Bavaria, than to prepare it themselves." (Mech. Mag. vol. xli., p. 471-2.) NOT from Munich.

But, say they who are unwilling to improve for fear

of the trouble it might happen to cause, we have neither Alps nor Andes in England, nor shall we go to the city of Quito to look for a brewery or a brewing site. True; neither have we Hungarian plains or Libyan deserts, nor can we travel here as Buonaparte marched with his army, as far as from Paris to Moscow, and scarcely see a hill all the way; but this is the grand question. We have thousands of hills and dales with gentle declivities, and hundreds of Alpine precipices in miniature, and above all things, this exceedingly variable and uncertain climate; and we have every reason to believe that the least level districts of England are the most noted for native beer; and we are accustomed to work upon larger mashes than they who inhabit those extensive territories have ever seen, and to whom the intrinsic value of British beverage is neither known nor understood; therefore it is that the author adopts the language of the Mantuan shepherd, saying:

"*Sic parvis componere magna solebam.*"

Who is there that has not read of, and perhaps seen, Ben Nevis, Ben Lomond, the Middletons, the Ochies, Fanna, and Blackhall? Helvellyn and Skiddaw, the Peak and the Peak beyond, the Cotswolds, the Mendips, Longmynd and Stiperstones, the Wrekin, the Clees, and Malvern? Snowdon Wyddffa, Plinlimmon, Cader Idris, Cader Frewyn, Arran Fowddy, and the Cradle? The Passes of Kildare, the Wicklow Shillelah country, Kerry, and Slieu Denard? Valleys and caves abound on the banks of the Clyde and the Findhorn; at Clifton, in Somersetshire, on the Avon, and at Ironbridge and Bridgnorth, in Shropshire, on the Severn; all rocks with rivers flowing through ravines deep between. Need we tell of Fingal's Cave, the Giant's Causeway, or the romantic scenery in North and South

Wales, Cornwall, Derbyshire, or among the Westmerian and Cumbrian lakes, or under the edge of Ingleborough and "Stainmore's wintry waste?" In Devon, Dorset, Hants, and many places round the southern, and indeed all the other coasts, sites so eligible might be chosen for our business, that refrigeration could scarcely be needed at any time of the year. The defiles through which the Severn runs, are in many places peculiarly suited to the purpose, from the facility of exportation afforded by the navigable river, and from the proximity of all essentials requisite to carry on the trade, such as hop-gardens, coal-mines, good water, and the best of barley; in short, nothing can be wanting excepting the persevering skill of a second Reynolds, to make such a district outvie Bavaria in all respects; besides which, England is now almost everywhere supplied with canals and railways. If, then, Burton and Edinburgh derive a good menstruum from the neighbouring hills, and afford facilities for its conversion and transport to all parts of the world, why not other places likewise? But the brewer has not yet arrived at that stage in his progress and practice, which will require him to examine subterraneous places, not having disposed of all the interruptions which annoy him in the cooling department, and which are principally contained under four heads, namely, severe boiling, a hot or variable atmosphere, the influence of climate, and the bad selection of utensils. The philosophy of climate shews to him the uncertainty of atmospheric action where it varies so exceedingly as in England, under all the influences of

1. Sun;	4. Aspect;	7. Cultivation;
2. Elevation;	5. Mountains;	8. Wind; and
3. Sea;	6. Soil;	9. Time of year;

and points out to him the eligibility of certain localities

in producing coolness, but excluding cold; determining the situations in which the desirable medium of temperature can be obtained with the least trouble and expense, his business here being not merely to cool, but to cool properly, so that ultimate perfection may follow the attenuating process. Of these nine influences more might be said, if want of space did not urge the compression of the subject, to make room for observations which are more directly practical; therefore, to be brief:—

1. The Sun.—The influence of this great luminary over physical climate and season, must be universally acknowledged, and the cessation of labour in the brewery during the hot months, affords proof of it. We read that in a part of Norway, at so high a latitude as 70°, the thermometer has been known to rise to 80° F., because the sun is a great while above the horizon, but that such heat is not generated in the dingles surrounding the Dofrafeld. In like manner in Bavaria, his horizontal rising and setting are prevented by the interposition of mountains; as in Great Britain, in the vicinity of Ben Lomond, and several others of the mountains named above, with many more, particularly those called pikes, near which, at certain seasons and in certain places, he rises or sets twice or oftener every day. Bouguer shews that the sun's rays have the greatest power when they act perpendicularly upon the earth's surface, and that when near the horizon, they merely glance along the ground, and many are absorbed and dispersed by the lower stratum of atmospheric media in which their passage lies; and that of 10,000 rays that fall on the earth's atmosphere, 8123 arrive at a given place if they fall perpendicularly, 7024 if the angle of direction is 50°, 2831 if but 7°, and only 5 if they come horizontally. This applies to Bavaria, where the me-

ridian heat falls almost perpendicularly on the sloping hills, leaving the valleys cool, and where the evening and morning tangential rays are reflected from the points of their contact, and absorbed by the cooling waters. This precisely accords with our lake districts, as Loch Lomond, Ullswater, Coniston, Windermere, Llyn Ceigin, Llyn Beris, and others, and with many snug creeks on our coasts, all noted for good home-brewed beverage.

2. Elevation.—The reason of this influence has become quite apparent since the discovery of isothermal lines, or distances of ascent to give equal heat, dependent on the quantity of level land, or of water covering the earth's surface, which causes the range of superficial heat to be regulated, in a secondary sense, by its distance from the shore. For instance, the curve of congelation formed by the position of the freezing point, which is every where said to be at 32° F. (though not correctly, as in the case of the boiling point, noticed at page 328), is said to touch the earth at the poles, but to be 3818 feet above the sea in latitude 60°, 6334 feet in 50°, 9001 in 40°, and 15,207 feet at the equator, taking the atmosphere at a mean temperature in each place. In the neighbourhood of Birmingham, or in latitude 52½°, if no local causes affected it, this curve of congelation would be at an altitude of 5705 feet; but there are days on which the thermometer, in exposed situations in that latitude, falls as low as 7°, or 25° below the said freezing point, whereas on other days it rises to nearly 90°, as has been shewn, which is higher than the mean temperature at the equatorial level; but these excesses do not appear to happen in the Bavarian brewing circle and season, whereas Englishmen like to be doing throughout the year.

3. The Sea, or continental position with respect to it.—This consideration is greatly in favour of the British

climate, giving to certain localities a temperature deviating materially from the isothermal line. According to the researches of the great Humboldt, in the Hungarian interior of Europe, between 44° and 50° of latitude, where there is an extensive plain of 20,000 square miles, round which numbers of mountains rise from 5000 to 10,000 feet in altitude, the mean temperature for August is 76·6°; but at Dublin, and other places on the coast of Ireland, from 53° to 56° of latitude, it is 60·8°; yet in Hungary snow falls as early as September, and lies till June, and Ireland is remarkable for mild winters and green hills; and in Scotland, at Edinburgh, in latitude 56°, the winters are said to be as mild as those of Milan, in latitude 45½°; and though the elevated terraces of land which lie along the Carpathians are accounted healthy, yet Hungary is termed "the grave of the Germans," from its inordinate and variable temperature; and Dublin and Edinburgh brew famous malt beverage, but Hungary does not.

4. Aspect.—The point towards which the country slopes, has a great influence on climate, of which the Bavarian northern inclination is a striking example; and "in the Vallais in Switzerland, the Alps are on the one side covered with ice, while vineyards and orchards flourish on the other." (Phys. Geog., p. 35, Society's Treatise.) The climate of the vale of Kendal, which stretches to the sea on one side, and is screened from the northern blast by the snow-clad hills of Westmorland on the other, is more temperate and steady than that of London, with all her fires and tepifying inventions; and we never hear of good, bright, fresh ale in a flat and open country, like the Wiltshire Downs, or the fine luxuriant cider counties of Somerset, Gloucester, and Hereford, or in the plains round Leicester, Manchester, the Fens, or Dereham, unless imported or brewed by a

more than ordinarily skilful workman; but Kendal ale has a high name.

5. Mountains.—It has already been shewn that acclivities affect climate in various important ways; in addition to which it may be useful to observe, that they attract the vapours of the atmosphere, condense them, and give rise to rain, which descends upon the valleys near their feet, and in the vicinity of lofty ranges is often violent, though in England this cannot happen to any very detrimental extent, but frequently, in dry seasons, is a local benefit; and they afford shelter from winds, which in our climate is a protection where the aspect is to the south-west especially. Much also depends upon the direction in which the chains run; for in narrow valleys, the sides of which reflect the sun's rays strongly in summer, the shelter from the breeze is injurious; but it is from this attraction of vapours, says Hogarth in the Physical Geography, that the chain of the Alps, running east and west, as many of our British ranges do, gives salubrity and fertility to the climate and soil of Italy.

The quantity of rain which falls in London annually, notwithstanding the fogs and damps which infest the place, is from 23 to 24 inches; and according to an elaborate investigation of the table of returns of the state of the thermometer at Sandhurst, on every day during 25 years, and before quoted, the mean temperature of the atmosphere is $51\frac{1}{2}°$ in $51\frac{1}{2}°$ of latitude; and it may seem strange that at Pekin, which has nearly the same mean temperature as Britain, the summer heat is greater than at Cairo, and the winter cold and severe as at Upsal, in latitude 60°; but Sweden is a mountainous and China an open country, and "rain is a very uncommon phenomenon in Egypt," as we have been taught from our school geography. At Kendal, under

the southern prow of the Westmorland fells, in latitude 54¼°, the quantity of rain is 60 inches in a year; and at Liverpool, latitude 53½°, the collection is 34 inches; yet Liverpool, like Kendal, from being situate near the coast, is fully as mild as London in winter, and much less arid in summer, when the more opulent residents of the south retire to those milder districts to recruit their health, vigour, and appetite. From this cause also, we may account for the length and coolness of the Alpine summer, and the oppressive heat of the Hungarian deserts, where good ales could not be brewed.

6. SOIL.—On this subject, much has been said in our third chapter; and we may here add that its nature greatly affects climate. "One soil acquires heat, keeps its acquired heat much longer, or reflects it more readily than another. One which, from its porous character, allows the rain descending upon it to pass freely into the earth, will emit much fewer exhalations than one which retains the waters near the surface. Thus clayey or marshy grounds lower the temperature, and, especially in hot and humid climates, affect the atmosphere in a manner pernicious to health; on the other hand, those which are light, stony, or calcareous, tend to make the atmosphere salubrious." (Phys. Geog., p. 36.) Now the Alpine apices are formed of granite; Bavaria is stony, and the plains of Hungary are sandy. Here again Kendal has a great advantage; for Kendal fell is a limestone rock, of a quality so pure, that portions of it have been converted into harmonical ranges, which, on being struck with a hard instrument, such as the mace of a dulcimer, form peals of the sweetest bell-music; and the soil which covers the limestone bed in the lower lands within a few miles of the town, produces some of the best barley in the world. But Kendal is not alone: look at Burton and its "plaster of Paris" soil; and at

Dorchester and the chalk hills many miles thence, as far as Hertfordshire; at Much Wenlock and the Franchise; at Buxton and Poole's Cave, the Peak, &c.; in Yorkshire at "Lahtle Yatton aside o' Roseberry Toppin;" at the natural walls of Nottingham; and even at Gotham, famed for wisdom of no common kind. Look at any of the hilly districts of England, Scotland, Wales, or Ireland, which are not too fully stored with metals, and there we may find brewing sites in abundance, fit for carrying on the business wholesomely, safely, effectively, and profitably, without much artificial refrigeration.

7. CULTIVATION.—The degree of improvement to which a country has been brought, is of material consequence: this may be very largely exemplified by the well-known fact, that the progress of agriculture has very greatly diminished the rigour of the American climate both in Canada and the inner United States. The slovenliness of the Bavarians, and the growth of their forests, help to keep the country cool; but though the proverbial industry of the Britons may tend to increase the brewer's perplexities, he can now avail himself of the recesses which afford channels for the mountain streams, and there harbour, like a fox, under the roots of the trees, where nothing else will grow, keeping himself warm in winter and cool in summer, and pay for his accommodation, which will be a thousand times more beneficial to the state, the community, and the owners of the soil, than all the smuggling that for generations has been carried on in some of those places.

8. WINDS.—Such is the power of wind, that in Siberia, as far south as the 58th degree of latitude, M. Pallas found the temperature of the air to be at the freezing of mercury, which is at 39° or 40° below *zero;* and at Melville Island, where Captain Parry wintered in 1820, the thermometer sank to 55° below *zero;* though the Nor-

wegians of Attenguard, under the 70th parallel, "contrive to raise corn" in their valleys, where sheltered oats and barley vegetate at an elevation of from 1500 to 1800 feet; and in some parts of that region the corn is sown and reaped within the course of seven weeks; the extreme rigour on one hand being attributed to the constant prevalence of wind in one direction, and the extraordinary growth of corn in the other, to its total absence. It is also in the absence of wind, that in New South Wales the thermometer rises to 110°, and at Pekin to that or 115°; but in Africa, the continual current of a *hot wind* raises the temperature to 125°, as noticed by Major Denham at Balbeis. These excesses, it is true, do not take place in Britain, though here, as in all other countries, the temperature varies according to the quantity of wind that prevails; and though a good breeze may be thought serviceable to the brewer in summer, especially if his coolers are lofty and open, yet as he never knows how strongly it will blow, or from what quarter it will come, other means of refrigeration are preferable. Wind is not uncommonly accompanied by rain; though by a proper regulation of the louvres in favourable seasons, he may admit the one and exclude the other.

9. The time of the Year.—The observations that have been made under the heads of *sun*, *aspect*, *mountains*, and *soil*, very greatly affect this remaining influence; and the information given from the Gentleman's Diary and elsewhere, might lead some readers to infer that the difference between one season and another was more a matter of chance than of actual disparity; but after all, there will be a winter and a summer to every year, the one very cold at times, and the other very often unendurably hot; and though some of the influences have a tendency to ameliorate towards a greater

equality in certain places, the annoyance of a variable atmosphere will continue more or less in all; therefore as all are quite insufficient, together with a better selection of utensils, to secure anything like uniformity in the pitching heat and fermentation of the worts, recourse must be had to such additional artificial auxiliary means as the skill of the human mind can invent, care being taken to give preference to the best.

Cold water appears to be the best agent when properly managed, and ought to be the most easily available; and most of the prejudice that can exist against refrigerators in general, must arise from the ignorance of persons who either misapply them, or have not chosen the most efficient and suitable; or perhaps from the obstinacy of persons who use fans, merely because they have them, and are unwilling to go to any additional expense in acquiring improvement. Worts cooled by fans cannot be brought down to so low a heat, or yet so expeditiously, as by a good refrigerator, whose foundation is running water, and whose supply is copious and perpetual. Yandall's or Wheeler's, Wigney's or Gregory's machine, has each its admirers, as has also Ramsden and Bennett's, and all of them are now so well known, that a description of any of them would be useless here, because it would be superfluous.

As winds and electricity often affect the vinous fermentation of malt liquors, the former by retarding and the latter by hastening them; and as in like manner they frequently injure the mash, as the worts undergo chemical decomposition and natural change, under the two excitements of saccharine transmutation and alcoholic conversion, which render them very susceptible of atmospheric contamination; so in the cooling process they must also have their share of natural action and influence, though the condensing worts conduce less to

aid the affinity, the action on the coolers being more mechanical than when decomposing.

A good machine is undoubtedly an invaluable acquisition, and the great variety of refrigerators which the ingenuity of man has introduced to the market, affords ample scope for choice in the selection. This is a delicate point in the process; and under circumstances such as occur, a wide difference is usually perceptible between summer brewed ales and such as are produced in cold seasons, if not brought about gradually, the best samples of the former being spirituous and light, but those of the latter full and rich, inferior qualities being less so, from the prevalence of electricity in the one case, and of wind and cold in the other.

Necessary Qualities of a Refrigerator.

1. *It should be composed wholly of tinned copper, or of as few and as tasteless metals as possible, every part being tinned on all sides to prevent contagion, and zinc should be particularly avoided;*

2. *It should be so constructed as to be perfectly suited to the locality assigned to it, and so as to facilitate the radiation and absorption of caloric, by exposing the greatest surface of wort to the cooling medium, that can be done consistently with size and expedition;* and

3. *Its construction must be such as to afford easy access to the wort and water chambers, when they require cleaning.*

The attemperating application of a tubular refrigerator where copious supplies of water are always at hand, is of inestimable service in a hot summer, when it is of the greatest importance to purify malt liquors of their yeasty dross; and often it is very difficult to do so; for though the attenuation may appear to have closed, the heat of the contents of the tun-barrels at

such seasons will seldom be lower than 58°, and will sometimes reach 70°; and as heat not only dissolves the barm in the body of the extract, but also perpetuates its solution and suspension, its obstruction by a colder medium facilitates its precipitation and consequent fining. But observe: this scheme is applicable only where cleansing into puncheons in warm situations is practised. In the first house in London, the porter is pumped through large refrigerators in its passage to the vats, that it may cool and be quiescent.

In some breweries the worts are pumped up from the pontoes into settling backs, and in these cases the refrigerator can be used both to expedite the cooling of the unfermented worts, and as an attemperator after fermentation, the coolers being planted higher than either the refrigerator or the settling back. Here Wigney's apparatus will be found the most useful; for as the settling back is generally placed several feet below the cooler, when it has been applied in the usual way, the following new appropriation of its services will in such concerns be found particularly advantageous. Fasten the straps of strong knee hinges across the refrigerator, with their shorter ends fixed on the upper edge of the hind part of the settling back, and connect the wort and cold-liquor tubes to it by means of union joints; then when the refrigerator is in use, it will stand upright, resting on the edge of the settling back through the aid of the joints, and is to be kept in this position by the common tackle fixed above. When this instrument is to officiate as an attemperator, it must be lowered into the settling back by means of this tackle, until it lies flat, and near the surface of the article to be racked; and now the malt liquor must be run on the back, and the coldest water that can be had must pass

through the attemperator. By this novel application of the machine, the settling back may be racked, and the liquor will be quite free from yeast and other impurities on the second day, provided that the previous part has been rightly managed ; and being condensed in bulk, in consequence of the abstraction of its caloric, it thereby becomes less pervious to subsequent heat, and is not so susceptible of secondary fermentation ; but care should be taken to tin the refrigerator inside and outside, and to keep it particularly clean, to prevent a metallic or galvanic contagion. This will be much better than waiting three or four days after cleansing for an imperfect depuration of the liquid in the tun-barrels or pontoes ; and being clean and fine, such an article will require fewer finings.

Though constant and thorough agitation with fans, winds, ploughs, and the like contrivances, may sometimes prevent the tangible appearance of a spontaneous fermentation in the coolers, and may render its effects less evident by driving the foam and mouldy spots from the surface as they rise, they present no guarantee against the engenderment of the calamity ; but, on the contrary, it appears reasonable, if we admit analogy, that by the numerous and gaping ripples and undulations which these implements cause, an enlarged and continuously new and changeable surface is exposed, as a temptation to the insinuating gases of the atmosphere. Different from this are the action and effect produced by

Masterman's Patent Refrigerator.—This apparatus, for which a patent was issued in March, 1844, to Mr. Thomas Masterman, manager and co-partner in Messrs. Masterman and Co.'s brewery, the Dolphin, in Ratcliff, London, is an erect machine, consisting of

1. A hollow cast-iron cylinder at the top, 18 inches deep, which he calls the "*Cistern*," with a flange at its lower end, and a short lateral flanged pipe of $2\frac{1}{2}$ inches bore, the cylinder in the specimen given being $13\frac{1}{2}$ inches.

2. Another cast-iron cylinder, placed underneath the former, of the same diameter, and 12 feet high, termed the "*Case*," flanged at both ends to correspond and fit above and below, and with a short lateral pipe at each end, like the former, and just above the bottom flange, a flanged arm-hole, 6 inches in diameter, closed perfectly water-tight by a door, except when repairs are being done.

3. A third cast-iron cylinder of the former diameter and 4 inches deep, called the "*Receiver*," placed beneath the "Case," and having flanges at its top and bottom, and a lateral pipe similar to the others.

4. Between the two contiguous flanges of each two in these three cylinders, a circular plate of gun-metal is inserted, the upper plate $1\frac{1}{4}$ inch and the lower 1 inch thick, in each of which 169 holes of $\frac{5}{8}$ths inch diameter are drilled, one in the centre, and the others in seven concentric and equidistant circles, $\frac{7}{8}$ths inch apart, the inmost circle containing 6, and the others the continued series 12, 18, 24, 30, 36, and 42.

5. The topsides of the holes in the upper plate are countersunk to receive conical heads soldered on the tops of as many brass tubes passing through the two plates; each tube half an inch in bore or a little less, and made strong enough to stand the test of the work intended.

6. Each tube has a brass collar an inch long, soldered on the bottom end, with a screw thread to its exterior, to receive a brass nut $\frac{7}{8}$ths in diameter, which is screwed

up with a leather washer over it, to the lower plate, and made water-tight by a composition of white and red lead.

7. "The Receiver" has a cast-iron bottom fixed and removable by nuts and screws; and in it is a brass cock for drawing off that part of the cooled liquid which remains in the refrigerator when the operation is over, and also for discharging the water afterwards run into the cistern to cleanse the machine.

The number of tubes (169) is not arbitrary, but the series may be extended to larger circles of tubes of 48, 54, 60, &c., by enlarging the diameters of the plates and of the three cylinders; but the patentee prefers increasing the *number* of his cases and their adjuncts, rather than their *size*, by connecting pairs of them together with the requisite pipes and cocks, and observes that five such machines would not occupy more ground than 10 feet by 3; and that if one of them should go out of repair, it could be detached, and the rest might be used without it; or the mere turning of the proper cock in the pipes for water and wort, would stop the circulation of each fluid beyond that barrier.

The mode of using a single machine is this. Cold water conveyed from a higher level is let into the case through its lateral pipe at the bottom, and ascends among the tubes till it fills the case all round them, and discharges itself through the other lateral pipe at its top, by which means a continued stream is maintained. The wort flows into the cistern, fills the tubes within the case, and the receiver likewise, and flows out from the latter through its lateral pipe. The stream is regulated by a cock in the discharge pipe, and by a thermometer having its bulb inserted within this pipe, and which has a water-tight orifice for the stem.

The construction of a double refrigerator is as fol-

lows: the *pair* must be on a level, having the lateral pipes of the cases opposite to each other. The pipe for conveying the cold water into these two cases is a strong upright one placed between them, extending above and below them, and communicating with them at top and bottom by means of their two pairs of lateral pipes. This communication is through two cocks fixed in this upright pipe, one between the upper lateral pipes, and the other between the lower, which cocks may be altered by merely turning their spigots to appropriate positions, so that the cold water may enter either one or both of the cases at their lower ends, and leave them, or the one it entered, at their upper outlet or outlets. The cistern above one of these cases, and the receiver below the other, has an additional lateral pipe, their orifices being on the same plane. A communication between this cistern and receiver is formed by a pipe connecting itself with each orifice, and having a stopcock in it, near the said orifice of the receiver. The feeding pipe from the coolers must also have a stopcock to it within each cistern. Thus the wort may be caused to flow from the cistern down its tubes into their receiver, and thence rising up the last-mentioned connecting pipe into the other cistern, descend the second set of tubes into their receiver, and thence be discharged; or this double refrigerator may be used as two single ones, discharging the worts at two different temperatures if required, or two kinds of fluid where necessary; or one case and its adjuncts may be used as a single refrigerator while the other is under repair.

A modification of this double machine is as follows: instead of an upright water-pipe between the two cases, connect the lower lateral pipe of one case with the upper one of the other, by a pipe; and thus the cold water will ascend in each case successively, and the wort will

flow in a contrary course through both sets of tubes and their receivers in succession, provided that the lateral pipe in the cistern into which the wort flows last be closed. In this modification the water and wort may easily be confined to either of the cases and its set of tubes, by a trifling alteration of the water and wort pipes, so as to allow repairs to be done to the parts of the other. When the liquid to be cooled comes from a common flat cooler, the refrigerator is fixed so that the tops of the cisterns are level with the upper edge of the cooler, or a little higher, to prevent a flow over the open tops; or if this liquid is contained in a vessel placed higher than the tops of the cisterns, they may be prevented from overflowing by a float, acting by a lever on a cock or a valve in each of the feeding pipes.

The small area occupied by this refrigerator is its lowest merit; for its power is so considerable, even when the refrigeration is commenced at a high temperature, and the quantity of cold water employed is comparatively small, that the usual area of coolers may safely be reduced one-half, and consequently much space is gained, which may be applied to other purposes; and besides the great saving in the outlay for coolers, the waste of that wort which adheres to those coolers is wholly avoided, as is that which attaches itself to horizontal pipes. The great injury done to the worts by long exposure to atmospheric air, after being cooled down to a fermentable temperature, is also avoided. The apparatus may be applied at any heat under boiling; but as the natural cooling from the top heat down to 100° is so rapid, it is not advisable to refrigerate at any higher temperature than about the 100°, and for the following reason:—" A greater length of wort may be turned out of the copper, and consequently a greater extract obtained from the goods, than when the great evaporation which takes place under such circumstances

is prevented." This is the patentee's view, to which he adds, "The wort receives no injury from exposure to the air on the cooler, while above the fermentable point, about 80°."

The perpendicular position of this refrigerator, and the course of the currents already described, are so essential, that neither can be altered without greatly diminishing the power of the refrigeration; for,

1st. As to its perpendicularity. However far the tubes may differ from each other in their relative power of transmitting heat, yet the wort will enter the receiver from each, when perpendicular, at precisely the same temperature. Call two of these tubes A and B; then it is clear that the wort will descend through both in the same time, while the temperature continues the same throughout in each; but if A transmit heat more quickly than B, then the column in A, becoming heavier than that in B, would descend the more rapidly of the two, and the warmer wort in B would not enter the receiver until the quicker run through A should have lowered the temperature in A to an equality with that in B. Hence the flow through A and B respectively, will be in exact proportion to their comparative power in the transmission of heat, being quickest in that possessing the greatest power, and *vice versâ;* which is an adjustment depending upon a law in nature, to which a non-viscid fluid is more obedient than the truest scales to a preponderating weight. But in any other position of the refrigerator than perfectly upright, the forces of expansion and gravitation would more or less counteract the discharge from the lower orifices of the tubes at an equal temperature, in consequence of the columns of liquid within the tubes being then of unequal length, and the pressure in them respectively being therefore unequal. This the patentee has very elaborately illustrated.

2nd. As to the course of the currents. The directions of these currents of wort and cold water, from the changes of specific gravity in each, consequent upon the variations in their temperature, induce a tendency to prevent any portion of the warmer wort and water above from mingling with the cooler beneath; because as the water warms it rises, and as the wort cools it falls: thus the coldest portion of the water is applied to the coolest part of the wort.

The cylindrical form and small diameter of the tubes give a *maximum* of strength to an extremely thin substance of metal; and the large number of tubes collectively present a very extensive surface, the interior superficies of a double machine, as used by Messrs. Masterman & Co. on the dimensions given above, and having 169 half-inch pipes in each case, giving a total of 531 square feet, by common mensuration; and as the rate of cooling varies in the compound ratios of the length and number of the tubes, if these be doubled, that will be increased four-fold; and again, if the refrigeration commence at a lower or cease at a higher temperature, or if a larger quantity of cold water be used, or its temperature be lower, the rate of cooling will be considerably increased thereby. The principles, then, brought into co-operation, and wrought out into practical results by this machine, ensure to it the *greatest attainable power*, where water is employed as a means of extracting the heat.

The directly upright posture of the tubes prevents any gravitated deposition of foul matter from the water on the outside, or from the wort within them, which would take place in any other position; and consequently the free passage of caloric from the wort to the water is not obstructed or retarded by such deposition, and thus transmission is aided by the pressure of the

two fluids. The straightness and erectness of the tubes likewise afford peculiar facility for cleansing them; for a stream of water run into the cistern immediately after use, acquires such force in passing through the tubes, that it cleanses them thoroughly; and if required, they may be scoured out with a rod and sponge, as gun barrels are. Neither is the machine liable to work itself out of order; but should it leak, which is all the injury that can befall it, any tube may easily be removed and replaced by another, and any common man can soon and easily repair it. When the wort remaining in the machine when the refrigeration has ceased, is below the upper edge of the square into which it is discharged, it may be driven out by cold water run into the pipes behind it, which would have the effect of cleansing them while moist with wort, and before corrosion could occur.

As the water used for refrigerating will never exceed the quantity required for the ordinary use of the brewery, it may be forced through the refrigerator on its way from the well to the liquor-back, and the refrigeration will be effected without any additional pumping. Another convenience is, that it may be made to supply the fermenting squares directly, as long as their upper edge is even with the bottom of the cooler, or a few inches below it, and of course the discharging pipe must then be led upwards, over the edge of the square; the only disadvantage will be, that the wort remaining in the tubes, if not expelled as before directed, when the refrigeration is over, will have to be drawn into pails through the cocks of the receivers; but this is soon done, as the quantity contained in the pair of cases is not 54 gallons; but expulsion is the readier way. The machine may also be very beneficially used by running ales through it, immediately after they have been sufficiently skimmed in the working squares.

The author has selected the following from a long series of experiments taken at the Dolphin Brewery, and furnished to him by the proprietors, who inform him that in their double refrigerator, one of their cases of 12 inches in diameter, contained only 118, and the other of 13½ inches in diameter, 168 tubes. They also remark, that in *small* or *ship's* beer, which they do not reduce under 70°, they can hardly pass it through the refrigerator with sufficient rapidity.

Ex. I.—*Temperature of Refrigerating Water* 52°.

Time.	Temperature, March 23.					Wort.	Water.
P. M. h. m.	State of Air.	Wort entering 1 refrig.	Wort entering 2 refrig.	Wort leaving refrigs.	Water leaving refrig.	Quantity in square.	In back after refrig.
4 0	52°	88°				B. F. G.	Brls.
4 15	52°	85°	75°	64°	72°	2 3 8	3
4 30	51°	84°	75°	63°	72°	6 3 4	6
4 45	50°	81°	73°	62°	72°	9 2 6	9
5 0	50°	78°	72°	61°	70°	14 1 3	12
5 15	49°	76°	70°	60°	68°	19 0 0	15
5 30	48°	70°	68°	60°	68°	23 2 6	18

Ex. II.—*Temperature of Refrigerating Water* 54°.

Time.	Temperature, March 26.					Wort.	Water.	Rate of running wort
P. M. h. m.	State of the Air.	Wort entering 1 refrig.	Wort entering 2 refrig	Wort leaving 2 refrig.	Water leaving refrigs.	Quantity in square.	In back after refrig.	*per* minute.
3 25	58°	88°	74°	63°	65°	Brls.	Brls.	Gals.
3 40	No alteration.	86°	74°	62°	66°	4	7½	12
3 55		84°	73°	62°	66°	9	15	12
4 10		81°	71°	61°	64°	14	22½	12
4 25		79°	70°	61°	63°	19	30	12

N. B. The refrigerators being filled with water and wort, 3 hours 15 minutes was the time when the feeding cock of the water, and the discharge cock of the wort, were opened, and those lets were never altered during the above time.

Ex. III.—*Temperature of Refrigerating Water* 55°.

Time.	Temperature, March 30.					Wort.	Water.
P. M. h. m.	State of the Air.	Wort entering 1 refrig.	Wort entering 2 refrig.	Wort leaving refrigs.	Water leaving refrigs.	Quantity in square.	In back after refrig.
2 30	54°	102°				B. F.	Barrels.
2 45	54°	96°	79°	63°	78°	4 0	4
3 0	52°	93°	78°	63°	78°	7 1	8
3 15	52°	90°	77°	63°	76°	10 2	12
3 30	52°	86°	73°	61°	70°	13 3	16
3 45	52°	83°	73°	62°	68°	17 0	20
4 0	52°	78°	71°	61½°	68°	21 0	24
4 15	51°	74°	70°	61°	68°	26 0	28

CHAPTER XII.

FERMENTING PLACES.

DANGER OF NEW OPINIONS — NATURE SUPERIOR TO ART — PERENNIAL STANDARD—CONSTANT TEMPERATURE VAULT— PROOF OF ITS SUPERIOR ELIGIBILITY—EXPERIMENTS—RESULTS AND REASONINGS—APPROPRIATE APPARATUS—THE CALORIPHAGON.

THE author of "Lacon" says in his deep book, that "many schemes ridiculed as Utopian, decried as visionary, and declaimed against as impracticable, will be realised the moment the march of sound knowledge has effected this for our species,—that of making men wise enough to see their true interests, and disinterested enough to pursue them;" and the "Young Brewer's Monitor" has this:—"There certainly exists a great affinity between brewing and chemistry, which renders it, like every other part of science, reducible to systematic rules and laws:" he has not, however, prescribed any of those laws, though he gives many rules, defined from practice only, and is therefore not a law-giver, but a commentator. Brewing is also in affinity with another science, which is that of physics; and physics and chemistry are evidently very intimate, and it becomes the brewer to search into physical and chemical causes with all the ability and ingenuity of which he is master, before he presumes to dictate to others what course they shall pursue.

In the former chapters of this treatise, and especially in the preceding, mention has been made of the four

great influences of evil. The first and last of those—severe boiling and unfit utensils, have been disposed of in the three last chapters, and the two others have formed an united subject for serious contemplation in the last; and hence it is advisable likewise to dispose of these forthwith; and as no means have yet been pointed out in practice, except such as have failed, something more adequate must be devised, though at the cost of vulgar reputation at the idea of propounding a new scheme.

A new scheme! ejaculates the incredulous sceptic, with a supercilious sneer. Another frantic speculation! responds the censorious cynic, with a snarling frown. Yes, saith the projector, and thanks to more considerate people, that we live in a country famed for freedom, where we shall not be condemned, through our vagaries or yours, to share the fate of greater and better men. Many of the great luminaries who shine in the firmament of science and literature suffered martyrdom for their opinions as abettors of treason, or dealers in magic or demonology, merely because their blind or designing accusers were slaves to the times which they themselves disgraced; and instances are on record which stain the pages of history, wherein even sensible men have joined in the clamour; as to wit, Sir Walter Scott, so long "the great unknown," was one who laughed at the "*monomaniac*" that first proposed to light the streets of London with gas; and the philosophic Brougham had an equally unfavourable opinion of propulsive locomotion by steam; but both have lived to recant, and the one to preside over a gas company, and the other over numerous steam committees.

When Socrates was allowed to select the instrument of his death, he chose poison; and when the fatal hour arrived, swallowed the draught with placid resignation;

and were the humble architect of the "Subterraneous Fermenting Vault" to be condemned to penal extinction as the reward of his audacity in attempting to alter precarious usage, he most assuredly would not prefer being nibbled to pieces by an insidious fry of paltry *criticula*, who know no good but self-appreciation; these creatures having in their hour no Roger Bacons, John Fausts, or Francisco Petrarchs, to feed upon, are glad to peck at any mote, atom, or animalculum, which lies in their way; and happy he who is not touched by their corrosive insolence! We may pity, in one sigh, the infatuation of the bigoted persecutors, and the suppressed talents of the victims persecuted; but being of human mould, and at liberty to breathe, something besides pity insinuates itself into our feelings when we contemplate on the fate of the great Galileo, whose benighted enemies could persecute his fame even beyond the tomb; or on that of the unfortunate Solomon de Caus, who for inventing the first steam-engine was thrown into the madhouse at Bicetre, where, being deprived of his liberty, he lost his reason in reality; but his invention was made known to the Marquis of Worcester, who visited him in his dungeon, pronounced him to have been "the greatest genius of his time," seized the opportunity, and published Caus's scheme in the "Century of Inventions," as one of his own. And now have we seen, in all the cases before us, after hundreds of years have elapsed, those ideas glowing in all their splendour which have gradually arisen from suppression, like a fire that has been raked, or like diastase which has been kept locked up within the cellular tissue of an amylous globule, till its native elasticity has burst its bounds, and set its astonishing powers in full action.

Reason and science have now so far triumphed as to

humanise the mind, and to have caused men to become free enquirers and cool deliberators, and in a great measure to have laid aside their prejudices. These blessings are now felt by all classes, with as little distinction as the remnants of their over-powerful impeders, *selfishness* and *misapplication through ignorance*, will permit. Their mightily influential rays are now expanding to the embracement of their final object, the prosperity and ultimate happiness of all mankind.

Having endeavoured, with as much plainness as his ability will allow, to point out the influences of the changeable British climate, and of the variableness of locality, as two of the great impediments in the way of constitutional perfection in brewing; having, in the exposition of facts, and the development of a series of principles, erected a beacon, however rude and dim, to guard the brewer against error likely to be productive of injury towards himself and the consumer; having, in short, prepared him to enter upon the work of Fermentation, by which his character as a manufacturer of a staple article must either stand or fall; the author conceives that his duty now is to prove to his readers, and strongly to impress upon their minds, the important truth, that to whatever degree of minuteness, in imitation of the operations of nature, the powers of art may be brought, still art is an insufficient substitute for nature, weak as an opponent to her, and oftentimes, as in the business before us, an unstable ally, if not a treacherous alien; since the most magnificent domes constructed by human mechanism cannot admit the brewer to the performance of his office with such certainty, or even such hope of success, as a Regen-Bavarian hovel, or as an obscure vault in Champagne.

Of the merits of the discovery sought to be elucidated in this chapter, let experience hereafter tell: the author

conceives it to be the best means of conducting the vinous fermentation ever proposed; for otherwise he would have withheld it from the public; and it must, of course, interest all the makers of fermented drinks in the world, as well as all who consume or are in any shape connected with them. Apparently, fermentation is the general means which nature employs in the decomposition and reorganisation of her works, as noticed in the last preceding chapter, page 333; under its influence nothing is lost, but merely changed in form and constitution, situation and tendency, and according to the extent of the exciting and perpetuating powers, such as moisture, heat, motion, &c., the principles of which are beginning to be understood by maltsters, brewers, vintagers, distillers, vinegar makers, and bakers; or by those of them, at least, who have opened their ears and eyes to the voices and writings of experimental chemists and reasoning philosophers. To attempt, in a dissertation on practical brewing, a general critique on the various productions and theories of all the eminent authors well and practically acquainted with vegetable chemistry, would be presumptuous and monstrous: a person, notwithstanding, who has attentively perused their several productions, and weighed them in the scale of comparison, may be excused should he advance and maintain a centred conviction, not recognised or even seen by any of them, especially as scarcely any two of them can be found to agree throughout on any particular theory in connexion with the subject before us, though some of them may certainly be regarded as improvements upon others; and his reason for craving an indulgence in the latitude of his thoughts may strengthen him with the impression that the system which he propounds is of as much national importance, both to the revenue and the public, as it is novel and

practicable within itself, and unique in its disposal and its real consequences to all. This is

The Constant Temperature Vault.

Extraordinary measures are necessary for the production of corresponding results; and it is clear from what has been shewn, and from the internal construction of breweries, as now erected, that the fermenting process now discovered to be essential and peremptory, cannot be regularly conducted in any of them; as they are all subject to the extremes which lead rapidly to vicissitudes and disasters, such as neither fire nor water, nor both, with men to help them, can controul, though only under such as are termed "moderate excesses of temperature," occurring at all seasons of the year, and sometimes not more so at or after the solstices, than at the equinoxes, whatever may have been done by sinking the vats below the floor. Year after year, and age after age, as long as the climate lasts, those changes, and greater than any that have been noticed, will succeed one another; and hence the necessity of devising a place that shall be uniformly so much warmer than the one extreme and cooler than the other, that the influences of weather and season cannot affect it, but it shall be exempt from both, and from all approximations to them. The principle of selection is plain, and is at once this: the temperature, to be uniform as regards its component material and the circulation of its air and waters, must be a deep hole in the earth; for nothing *upon earth* that has been discovered or thought of will answer the conditions of this grand problem; nor does it at present appear capable of solution in any other way; but if the place be already formed, so much the better.

Through the investigations of Humboldt, Laplace,

Arago, Bischoff, &c., the doctrine is fully established, that the centre of the earth is very hot, and that the central heat is decreased in all directions towards the outside of the ground, a stationary temperature obtaining at a comparatively slight depth, which is determined by the course of an "*Invariable Stratum*," below which the internal increase amounts to 1° F. for each 15 English yards deep; but the contrary fact is observable, that the temperature of the ocean decreases proportionally; so that in various latitudes, where the surface heat, according to Sabine and Kotzebue, is 83°, it reduces to 77° at 250 fathoms, 75° at 300 fathoms, and 55½° at 1000 fathoms deep; and, according to Captain Ross, at 60° 44′ of latitude the temperature was 30° at 100 fathoms, 29° at 200, 28° at 400, and 25° at 600 fathoms; so that every where the bulk of water present contributes to the coolness of the place: a fact which is pretty well exemplified in the foregoing chapter, and points out the necessity of having plenty of this useful fluid always at command.

In the work on Physical Geography, in vol. iii. of the Society's Natural Philosophy, is a note stating that M. Lacroix, in his treatise on the same subject, says, that "in the caves below the Observatory at Paris (lat. 49°), about 80 feet below the surface, Fahrenheit's thermometer stands between 52° and 54°, scarcely ever varying 2°; while above, the difference of temperature between summer and winter sometimes exceeds 90°. In the salt mines at Wielicza in Poland, lat. 50°, from the depth of 320 to that of 745 feet, the thermometer stands at about 50°. At Cairo in Egypt, at the bottom of Joseph's well, 210 feet deep, it is stationary at 70°; and in the mines of Mexico, lat. 20°, 1650 feet below the surface, at 74¾°. In these depths we see how the temperature increases on approaching the equator, and,

as we have seen, on approaching the earth's centre also; and they shew us, which is most important here, that an uniform heat may be found and maintained throughout the year, without dreading the uncertain atmosphere of July and August, or trusting to the equally uncertain variations experienced in October frosts and November fogs, or in the alternations of gleamy, stormy, smiling, frowning Spring.

The mean temperature at the equator being 81½°, the theorem for other places, as laid down by Phillips in his Geology, is 81·5 + *cos. lat.;* therefore, lest the observant reader should experience any difficulty in finding the Invariable Stratum, the following Table of the cosines of latitude for England, taken at distances of five minutes from each other, is compiled for his information from Dr. Hutton's Mathematics, the earth's radius being always considered as unity, and that of all other circles the same. The Table is here given, because the principles are not accessible without considerable expense.

Table of Cosines of Latitude for England.

50 Degrees.		51 Degrees.		52 Degrees.		53 Degrees.		54 Degrees.		55 Degrees.	
Min	Cosine.	Min	Cosine.	Min	Cosine.	Min	Cosine.	Min	Cosine.	Min	Cosine.
0	.642787	0	.629320	0	.615662	0	.601815	0	.587785	0	.573576
5	.641673	5	.628189	5	.614515	5	.600653	5	.586603	5	.572384
10	.640557	10	.627057	10	.613367	10	.599489	10	.585429	10	.571191
15	.639489	15	.625924	15	.612217	15	.598325	15	.584250	15	.569997
20	.638320	20	.624789	20	.611067	20	.597159	20	.583069	20	.568801
25	.637200	25	.623652	25	.609915	25	.595991	25	.581886	25	.567604
30	.636078	30	.622515	30	.608761	30	.594823	30	.580703	30	.566406
35	.634955	35	.621376	35	.607607	35	.593653	35	.579518	35	.565207
40	.633331	40	.620236	40	.606451	40	.592482	40	.578332	40	.564007
45	.632075	45	.619094	45	.605294	45	.591310	45	.577145	45	.562805
50	.631578	50	.617951	50	.604136	50	.590136	50	.575957	50	.561602
55	.630450	55	.616807	55	.603976	55	.588961	55	.574767	55	.560398
60	.629320	60	.615662	60	.601815	60	.587785	60	.573576	60	.559193

Example 1.—To find the mean temperature at London, in latitude 51° 40′ N. cos. 51° 40′ = .620236; and 81·5 × .620236 = 50·549234, or rather more than 50½°.

Example 2.—If the exact latitude does not occur, as at Devonport, lat 50° 22¼′, we have cos. 50° 20′ = .638320, and cos. 50° 25′ = .637200; difference, 1120; then say, 1122 × 2¼ ÷ 5 = 504, and .638320 — .000504 = .637816, which × 81·5, is 51·982004, mean heat there.

To prove the correctness of this theory as a general principle, we may refer to Professor Bischoff, who shews in his "Researches," that London lies 14 feet above the sea, and the mean temperature of the soil is 51·01°, which is half a degree more than deduced from the Table, and may be attributed to the presence of water. This is in some measure confirmed by Mr. Roebuck's experiments, who found that, according to three years' observations, the mean temperature of the London atmosphere was 52·16°, and that of Edinburgh 47·68°; and he adds that the mean temperature of the springs was 51,01° about London, and 46·985° round Edinburgh; so that the influence of water in each case affects the surrounding medium about 1° F. See Philos. Trans. 1775, p. 450.

Past experience has nevertheless shewn that the mean temperature of a place is often below that of a spring whose temperature is constant throughout the different seasons of the year; and Bischoff observes that the mean temperature of the soil cannot be deduced from the observations on wells *with exactness;* but that an approximate result may be found by trying many different wells and taking an average. With constant temperature wells, however, we may venture an analogy to connect a fact, and may safely deem it conclusive.

Taking the external decrement of variation at 1° F. for every 265 feet, the medium between Dalton's and Nixon's statements; and believing, with Phillips's authorities, that the internal increment below the invariable stratum is 1° F. in each 45 feet, we may infer that a stationary heat exists at a depth not materially affected by either of those graduations, but between them. The internal temperature of the earth does not, at all times and in all places, entirely depend upon the

latitude, or upon the depth of the place, any more than the temperature outside does upon the elevation; for the conducting powers of the soil, be it remembered, depend upon the rise and aspect, and on the principles of cultivation, the temperature of the waters that pass through it, the continental position, the durations and intensities of extreme external light and air, the materials composing the interior, and other things, all of which tend to produce differences; but the cure is, that extraordinary variations can be detected, accounted for, and avoided, how? *By the principle here laid down.* In our latitude the annual mean temperature generally occurs about April and October, or after the equinoxes; and the *maximum* and *minimum* on each side are extremely irregular and uncertain, as already demonstrated, and yet still a medium *must* obtain.

The following corroborative testimony in favour of the present theory is from the "*Gallery of Nature and Art*," by John Hunter, M.D. F.R.S. (See the Penny Mechanic, vol. i. p. 242.) "The great difference between the open air and that of deep caverns and mines has long been taken notice of, both as matter of curiosity and surprise. After thermometers were brought to a tolerable degree of perfection, and meteorological registers were kept with accuracy, it became a problem to determine what was the cause of this difference between the heat of the air and that of the earth; for it was soon found that the temperature of mines and caverns did not depend on anything peculiar to them, but that a certain depth under ground, whether in cave or mine, or a well, was sufficient to produce a very sensible difference in the heat. In observations of this kind there was, perhaps, nothing more striking than that the heat in such caves was nearly the same in

summer and winter, and this even in changeable climates, that admitted of great variation between the extremes of heat in summer and cold in winter."

The Parisian experiment is thus confirmed by the theorem: the cosine of 49° is .656059, which being $\times$ 81·5, gives 53·46881° for the temperature at that place, which is within the limits noticed by Lacroix. The late Dr. Hutton, alluding to this subject, and particularly to the French test, says, in his *Mathematical and Philosophical Dictionary*, that it has been found by observation, that the same degree of heat occurs in all subterranean places at the same depth, varying a little at different depths, but is never less than 36° F.; and that at 80 or 90 feet, and sometimes much less, temperature deviates little, and is generally about the mean annual heat. With respect to the Observatory at Paris, he is more minute than Lacroix, for he says that the temperature there, at 90 feet deep, is 53½°, varying only about half a degree *in very cold years.* He also informs us that Mr. Boyle kept a thermometer a whole year in a cave 80 feet deep, and found it stationary the whole time; and that Dr. Withering made a similar experiment on a well at Edgbaston, near Birmingham, the temperature of which was 49° in every month of the year 1798. This is another convincing proof that Phillips's geological theorem is true; for the natural cosine of the latitude of Birmingham, 52° 30′, is .608761 by the Table, 81½ times which is 49·61402°; from which if we deduct only half a degree for the proximity of water, we have Dr. W.'s standard to a nicety.

Dr. James Johnstone, of Birmingham, in an examination before a Committee of the House of Lords on the subject of the Brighton Railway tunnel, stated his

opinion, that if a tunnel 600 yards long were 80 feet below the earth's surface, it would have a constant temperature of 52° or 53°; and consequently that, in the heat of summer, which is estimated at 76°, the vicissitudes would be 20° or more on immerging into and emerging from the tunnel; and that, on the contrary, when the wintry atmosphere was down at the freezing point, or 32°, the iniit and exit would also cause a difference of 20° in the contrary extreme; and that he did not think it possible to ventilate such a tunnel, so as to bring it to approximate to the existing state of the atmosphere, because the interior must necessarily take the temperature of the surrounding parts. The latitude of Brighton is 50° 50′, or thereabouts, and its cosine .631578 gives 51·47361° for the mean temperature or invariable stratum, which by the theorem lies rather too near the earth's surface, but is full as high as can be required for a fermenting heat; and in general, in the south of England, the mean temperature would be found quite high enough without excavation, did not the external influences affect it to some depth: the brewers of those districts should, therefore, avail themselves of the use of mountain springs, which are generally colder, and consequently the air also, in the grottoes, caves, and mines, through which such waters pass, partaking of the same temperature, and maintaining it as uniformly as the fountains supply the waters. This still greater advantage ought always to be taken in the elevated parts of the country, as there is greater danger in suffering the fermentation to run too high in a southern latitude, than in finding a secluded northern one in which it will drop too low, as in the mountainous districts of North Wales, for instance, lying between 52½° and 53°, or about 53°, the theorem gives

49·04792°, which would be quite high enough for practical purposes, without digging deep, were it not for external changes of the seasons or the atmosphere.

Bischoff remarks that in mountains 7000 or 8000 feet high, the temperature of springs, with few exceptions, is from 38½° to 41°, and that this shews how springs descending from great heights *bring down cold with them;* and, as he says, of course the more copious they are, the quicker their subterranean course, the steeper the mountains, or the nearer their channels approach the vertical position, and the less they are adulterated on their way with waters of a different temperature, the greater is their accompanying "degree of cold." This is theory united with experiment; but without speculating in such lofty altitudes, by taking the heights of some of our hills, ordinary and extraordinary, we have the Observatory at Greenwich at an elevation of 213 feet, in latitude 51° 29′, and the Wrekin in Shropshire, which commands a survey of nearly the whole county, 1320 feet, in latitude 52° 40′, giving the result and temperature by the Table 50·75347° at Greenwich, and 49·42576° at the Wrekin; and as the increments have been taken at 265 feet for the first external degree, and at 90 feet for the first internally, measured from the point of mean temperature, and 45 feet afterwards, it follows that in a cave dug to 100 feet within the bowels of the Wrekin, the heat would be the same that is at the Observatory, and that at all subsequent depths after the first 90 feet the internal heat at Greenwich would be 1⅓° more intense than in the Shropshire hill, though the altitude of the one position would still remain at 1100 higher than the other; and this depth of 90 feet for the first degree may be estimated from theory as a correctly constant step, being a fair medium between the 265 feet of

external atmospheric decrement arising from elevation on the one hand, and the afterwards constant increment of 45 feet *per* degree F. of subterraneous heat on the other.

We have seen (Chap. X. p. 309—11) how the Scotch and Bavarian brewers pitch their worts for fermentation, and that the latter never suffer their gyles to rise higher than 50°. Experience tells the author, as an English brewer, that, generally speaking, and more particularly in the southern counties, 52° may be allowed as the *maximum*, where the resultant beverage is meant to keep long and sound. The "Young Brewer's Monitor," many of whose rules and reasonings are more consistent than those of most, recommends not to exceed 64° in the coldest weather, 60° in mild, and "as cold as the atmosphere will admit" at other times; but being favourable to a natural course, and never mentioning the art of refrigeration, he wishes to preserve as much uniformity as possible, not considering that the mean temperature, which at times he cannot approach without artifice, is the guide which nature chooses for those who wish to obey her standard laws, and that without such a pilot the adventurer is liable to founder; and consequently, that though, in the latitudes of southern England, it is warmer by some degrees than in Scotland, according to physical geography, yet the influences, as demonstrated in Chapter XI., and especially local shelter and exposure, require many deviations from the formal continental rule, and the requisite difference is less accordingly; but nothing short of direct experiment can fix upon the first point below the surface of the ground, at which a constant temperature can be determined to exist. When obtained, it will be everywhere found within less than 100, and generally not more than from 80 to 85 feet of the surface, whether

the perforation be directly downwards, horizontal, or oblique: it seems rather to follow an undulating course than any other, much in accordance with the form of the exterior surface, though more gradual, and in no instance abrupt.

Though undoubtedly the medium in that part of Scotland which lies under the 56th parallel, is locally much cooler in reality than the places that are in the 50th, and consequently a lower constancy of temperature may be ascertained, yet as no part of England is below the latter line, except some of the Scilly isles and the promontories and rugged lands in the south-western angle of Cornwall, where full allowance may be made for elevation, projection, and contiguous water; this will bring every part of England within the prescribed range; and in the more northern parts, if the height of latitude be allowed to have any weight as a natural cause in the production of natural results upon native growth and conversion, a temperature of from 45° to 50° is more appropriately adapted to the scale of locality than the 52° mentioned as the utmost limit of constant safety for the southern parts of the kingdom. Were the Scotchman to pitch at 47°, he would find it more conducive to his interest, because more in accordance with the natural circumstances of his locality than 52°, and indeed he sometimes pitches lower; and it appears from the experience of the Scotch brewers of the modern school, that 47° is just the heat that will suit him; and at the other extremity of the kingdom the author knows from his own observations, that the generality of wells in Dorsetshire and Hampshire differ very little in temperature from those round Birmingham, if sunk to a distance of some 30 yards, though shallow reservoirs vary considerably in both places, as from fluctuations in the seasons may be expected; and within the

last few years, when he has attended to the subject more particularly than in former seasons, he has found very little difference between the numerous springs round Plymouth and the chalk hills near Dorchester, &c., and those in London, Lincolnshire, and Oxfordshire, whether in summer or in winter, with very slight variation even in the extremes of season: in short, he believes that a vault might be made all the way from London to Edinburgh, to preserve a constant temperature throughout, and that the depth would not vary more than some 20 or 30 feet between end and end.

The following Table, constructed on the same principles as the preceding, shews the depth to which theory would require an excavation to be made in England and the lowlands of Scotland, according to the parallels of latitude respectively crossing those places, in order to obtain the uniform high pitching temperature of 52°; from which it will be perceived, that in the south of England it would be almost impossible to obtain that standard without previous ascent, were it not for a cool constituency, or for maritime proximity rendering the situation more temperate than the isothermal continental standard; for though the theorem gives a higher result at the lower latitudes, experiment confirms the fact that there, as in mid latitudes, the 80 or 90 feet of perforation will secure uniformity of temperature: a proof that the coasts of the "sea-girt isle" are considerably elevated above the continental level. The depths here apportioned to the different latitudes are calculated at 30 yards for the first degree of deficient latitudinal heat, and at 15 yards for each of the others; that is, multiplying any deficiency *less* 1 by 15, and adding 30 to the product, or multiplying 1 *more* than that deficiency by 15; a mode which will be found novel and conclusive in principle; but it does not by any

means follow that those depths are to be rigidly insisted upon, but that the *maximum*, especially in the higher latitudes, should be avoided in practice. The only practical use of this Table is to show that, philosophically considered, the northern parts of the kingdom admit of a lower standard temperature than the southern by some degrees, and that the worts ought to be pitched accordingly.

Table of Excavations to produce an uniform Heat of 52°, *according to the Degree of Latitude of each Place named.*

Latitude.		Natural Cosine.	Mean temperature near level of the sea.	Deficiency of temperature to complete 52°.	Depth required to be dug.		Names of Places lying under or near the same parallels, and therefore giving like theoretical results, as intermediate Places must give intervening results.
D.	M.	Decim.	Deg.Dec	Deg.Dec	Yds.	In.	
50	0	.642787	52.38714	None.	None.		RUAN, Cornwall; St. Martin's, Scilly; Eau, France.
50	30	.636078	51.84035	0.15964	17	14	BODMIN, Callington, Ashburton, Portland Bill.
51	0	.629320	51.28958	0.71041	25	24	HARTLAND Quay, Taunton, Cranborne Chase, Downton.
51	30	.622515	50.73497	1.26502	33	35	LONDON, Llandaff, Maidenhead, Mouth of Thames.
52	0	.615662	50.17645	1.82354	42	13	TEWKESBURY, Fishguard, Buckingham, Neyland.
52	30	.608761	49.61402	2.38597	50	28	BIRMINGHAM, Plinlimmon, Market Harborough.
53	0	.601815	49.04792	2.95207	59	10	NEWCASTLE-UNDER-LIME, Malpas, Sleaford, N. of Norfolk.
53	30	.594823	48.47807	3.52192	67	30	MANCHESTER, Leigh, Doncaster, Caistor, Kirton.
54	0	.587785	47.90448	4.09551	76	16	BOWLAND Forest, Mouth of Lune, Knaresborough.
54	30	.580703	47.32729	4.67270	85	3	ST. BEES HEAD, Shap, Yarm, Guisboro', Whitby.
55	0	.573576	46.74644	5 25355	93	29	SOUTH SHIELDS, Longtown, Annan, Glenavon Bay.
55	30	.566406	46.16209	5.83790	102	20	CHEVIOT HILLS, Jedburgh, AyrMoss, Tweedsmuir.
56	0	.559193	45.57423	6.42576	111	14	LOCH TARBERT, Inverneil, Falkirk, Dunbar.

It appears hence, as before observed, that 52° is too high a temperature for Scotland and the north of England; that the theorem only fails as a principle round the Lizard of Cornwall; and that there also it will

apply, if $1\frac{1}{2}°$ be allowed for water and irregularity of surface.

Let the reader pay such attention to this Table, that its design be not again misunderstood. It is correct, and agrees with the temperature of Paris, Limerick, the midland counties of England, and all other places not maritime, or affected by local causes: therefore, let not any one suppose, that, because theoretical examination and comparison give the above results at the extreme, in accordance with a fixed principle of 52° as a point, the invariable stratum lies 100 yards deep in Scotland, and is not to be found in Cornwall; for a philosophical theory thus laid down does not represent an absolute fact, but is merely an index to a system. If it be held true, as in extensive territories, even then the brewers of the north would not have to dig deeper than is here indicated, however elevated their sites, and the southerns would have only to select temperate situations, and there to carry on their operations according to the Bavarian plan, arming themselves against excessive variations.

To illustrate this doctrine by proofs, let us refer to the Artesian well near Paris, as described in the Penny Magazine, No. 617, where we are informed, that during the progress of the works at Grenelle, where this well is sunk, opportunities of ascertaining the temperature of the earth at great depths were not neglected; for knowing that the thermometer always stood at 53° or $53\frac{1}{2}°$, at the depth of 30 yards, in the well of the Paris Observatory, they found it to do much the same at Grenelle, that at 440 yards it rose to 74°, and at 550 yards to 79°; and when they bored to 602 yards, the temperature of the water which rose to the surface was 81°, which corroborated their previous calculations to a nicety. The increase, therefore, in that district appears

to be 1° F. to each 20 yards of internal descent, which is deeper than as before-named, owing probably to the cool quality of the strata, being chiefly limestone, chalk, and clay; but shews at once that if the brewer digs beyond a certain depth, his worts will soon be in danger; he has therefore only to ascertain his position by means of his thermometer, and where it once takes its stand at the proper indication, there to take his also. Whereabouts that must be, the following curious narrative, extracted from the *Times* newspaper, of November 6, 1841, will help him to determine:—

"A Subterranean Brewery.—There is near the Marché aux Chevaux at Paris, a most remarkable brewery, in which it is said very excellent beer is made. The owner, M. Chapnis, suspected that his house and court were placed over the catacombs of the city; and, wishing for more cellar-room, he bored and ascertained that it was as he had thought. Sure of success, he immediately set to work and built a stone staircase of 87 steps, through the spiral of which the liquid necessary for daily use might be brought up by the aid of a windlass. The staircase, however, was the least part of the work, for at the depth of 55 feet a void was found, caused by an accidental falling of the earth. M. Chapnis got this cleared, and then placed great columns to keep up the bank of stone upon which the Faubourg St. Victor and St. Marceau stood. Upon descending the steps, a large cavern is entered, the effect of which is very fine and picturesque. Undoubtedly M. Chapnis has the vastest and most extraordinary beer-cellar in the world."

It is somewhat remarkable that M. Chapnis and the author, unknown to each other, and unheard of by each, should have had the same end in view at the same time, and that period probably not a short one,

as M. C. must have been months in boring, building, and brewing, though this secret does not appear to have been revealed in England till some six months after the sealing of the present patent. In the interim, the patentee sent down to Ironbridge, in Shropshire, to his agent there, correct thermometers, previously proved, requesting him to take some experiments in that romantic glen, for the purpose of publication in his work; and the result is nearly as he anticipated.

In a place called Lincoln Hill, near the corner of Coalbrook Dale, the interior of which consists of a series of irregular caverns, formed by the abstraction of limestone, where he took his first experiment, the issue was at once convincing. These caverns are thus described by him:—"Lincoln Hill, at Ironbridge, forms an extensive angle of the Wenlock formation, mentioned by geologists, and is separated from the main body of that extensive range by the Severn, which runs between this detached part and the parishes of Broseley and Benthall, which fall upon the river by a steep descent on one side, as that of Madeley, in which Ironbridge and Coalbrook Dale are situate, does on the other, forming one of those deep ravines through which this river flows, and which here appears as if it had been caused by some sudden catastrophic severance, the opposite strata exactly corresponding to each other. The spot selected for the experiment is at an elevation of 150 feet above the Severn, in the middle of a defile originally hollowed out by blasting away the upper stratum, and appears as if once meant to form a hollow way. The principal cavity at the upper end of this place has several contiguous mouths, in at one or another of which the workmen daily enter, and thence descend by an irregular slope, formed by the dip of the strata, into different parts of the excavated hill. These caves lie open to the atmo-

sphere, and are freely ventilated; so that an allowance of some 2° or 3° must be made for the influence of atmospheric air in producing rarefaction and condensation, according to external season. In this instance, the temperature without was 57° at going in at 6 A.M., and 58° on coming out at 8; but, on exploring the interior, the thermometer gradually fell to 52°, where it remained nearly stationary throughout, but rose half a degree near the foot of a shaft 64 yards deep, and 160 yards from the entrance; and at one place, where water dripped in from above, the temperature was somewhere about 51½° or 51¾°; then, standing at a small fire which the men had made about 20 yards from the entrance, the mercury soon rose to 61°, and there stood; and this is the point to which it again rose in the middle of the day, when hung up in a room without fire."

Several other trials were afterwards taken, all tending to confirm the belief that the temperature of these caves at any distance above 25 yards from the entrances, (aspect S.) ranges constantly between 50° and 53½° F. It appears, too, that this uniformity of temperature extends to a considerable depth, as the foot of this shaft is just level with the bed of the Severn; and if one degree be deducted for the excess of depth beyond the theoretical allowance, the general temperature at the assigned point of descent will be reduced to 51°, as in an experiment afterwards taken near the river side, at the distance of 100 feet within, it was found to be, though the thermometer outside was at 60° before and after the observation. It is worthy of notice, that this temperature is dependent on the depth below the local surface, and not on any minute comparison with the level of the sea, above which, as appears by various surveys of the Severn to ascertain its fall, Ironbridge is about 130 feet.

Another experiment was taken on the Benthall side of the river, within the entrances of two orifices, there termed "footrids," directly overlooking the bridge in a northern aspect, and declining inwardly from elevations of 93 and 100 feet above the river. These footrids are penetrations made in the side of the hill, within which are railways, to facilitate the transit of the minerals from their beds within, to their destination outside, whither they are drawn by animals; and the mineral here obtained is fire-clay, which is dug from beneath the limestone. In the lower of these, at 40 yards within, which was as far as the light from without would allow the index to be distinctly read, it indicated as many as 56°; but in the upper, which was abandoned by traffic, the temperature at the same internal distance, and more on the decline, was no more than 54½°, where the atmosphere, which was at 64° without, had free and direct access.

A third, and decidedly more successful experiment than either of the foregoing, was made at the WHIT-WELL, a never-failing spring of *constant temperature*, on the edge of Gleaton Hill, four miles from Ironbridge, and one from Much Wenlock, about 30 yards out of the road from the latter town to Buildwas and Cressage. The situation is a little romantic, having formerly been a baptismal fountain, whence its title, but is at present obscure; the well, which has a northern aspect, being a rude cylindrical vacuity, two feet in diameter and 30 inches deep; but the water is only nine inches. The well is covered over by a stone, on which the observer may sit while his thermometer adjusts itself to the fluid medium.

The temperature of this spring is 50½°, and so cool is the vicinity, that on the 28th of September, when the atmosphere was at 62°, one half of the corn in the con-

tiguous fields was uncut, and the other half unhoused: a proof that though the temperature of the well cannot affect the ripening of the crops, aspect has much influence over temperature, and exposure to the meridian sun causes many extensive variations in the atmosphere to which a northern aspect is not liable; and it also proves that at the internal source of the spring, an invariable stratum of heat at 51½° exists; for it was found throughout these experiments, that the presence of water made a difference of 1° or 1½°, according to its quantity. Since, then, a constant temperature can be had, how much better would that answer the brewer's purpose, than his present exposure to every annoyance and injury that heat and cold, and wind and calm, and sun and shade, can inflict! Take this contrast: Leighton, in the preface to his Shropshire Flora, gives the following account of the seasons at Shrewsbury, 11 miles from the Whit-well: "Temperature of the air, derived from daily observations during 1832—3—4:—Mean annual temperature 50.97° by observation; 51° 9.72′ by calculation of latitude. Difference of hottest and coldest months 26.070°. Mean temperature of seasons: winter, 40.5°; spring, 51.63°; summer, 61.66°; autumn 51.74°. Mean difference of day and night, 32.8°. Mean annual range between the extremes, 61.73°. But no such range occurs within Gleaton Hill.

Several other experiments were taken in this neighbourhood, all of which tend to prove that the internal heat increases with the depth, and the external deviation in proportion to the time and circumstances of exposure to the solar power. The fountains were found to be the coolest, the tributary streams warmer, and the Severn warmest of all, being in the autumn, before the sun's influence descended below the medium, about 56° on the average. Another course of experiments was taken in

order to shew that the invariable stratum does not lie below the depth of 90 or 100 feet.

In a large coal mine, called the "Meadow Pit," at Madeley, into which the observer descended a perpendicular shaft 256 yards deep, and afterwards pervaded the interior to the distance of 450 yards, going thence in three several directions, along subterraneous passages called "lanes," which conducted him to as many points in the breastwork of 410 yards wide, where the colliers were at work, he found the temperature to vary between 67° and 70°, according to locality and attendant causes; the lowest being in a stable, constructed in a recess near the shaft, and the highest at a part of "the face" of the stratum, in a narrow passage not exceeding 50 yards long and 5 feet high, in which were ten lighted candles burning, ten breaths respiring, and eight men hard at work "holing," their naked bodies teeming with perspiration. In another part of the breastwork, a little on the ascent, where seven other men were similarly employed and more widely scattered, the temperature was 68°. Here it will be seen that though the increase of heat, according to the depth, is more considerable in this district of dry mineral combustibles than at Grenelle, it does not exceed the estimate of philosophers, thereby confirming the doctrine advanced; for though the foot of the shaft is only 476 feet below the bed of the Severn, it is 768 feet from the summit at Madeley. Another remarkable fact must not be overlooked, which is, that during the descent at 5 in the morning, which occupied about 8½ minutes, the thermometer rose from 58° to 66°, and continued to rise to 68° before it became stationary at 67½°, where it again stood before coming up at 1 in the day, and that in the ascent it altered little or nothing, though it indicated a rise; for the fact was, that being a fine brilliant day,

the atmosphere above had risen to 74°, being 16° within the 8 hours he was underground.

Let not the brewer despair of finding a perennial and applicable temperature, reside where he may, even be it in the vicinity of coal mines; for the author having seen some valuable information in the "Chemist," respecting the mines and miners at Elland, near Halifax, by J. S. Hiley, Esq. M.B.; a gentleman who has frequently favoured the scientific world with his valuable philosophical announcements; and having perceived, through him, that those mines are shallower and more humid than they are in Shropshire, instituted inquiry there too, and obtained from Mr. Hiley the following important particulars. "The result of a variety of observations enables me to state with tolerable certainty and correctness, that the average temperature of mines of the depth specified, (30 yards,) amounts to about 51° Fahrenheit. I may refer you for further particulars on this head, to the 23rd number of the Chemist. The temperature of the different springs in the parish of Halifax ranges between 47° and 52° F. This would seem to be confined to about 20 or 22 yards from the surface of the ground. Below this point the thermometer begins to ascend; for at 26 yards down it stood at 53°; at 30 yards down at 55°, at 40 yards down at 56°, at 50 yards down at 57°, and at 60 yards down at 60°. Another observation in a different shaft, gave the following results: at 80 yards from the surface the mercury rose to 58°, at 100 yards to 59.5°, and at 126 yards, which was the bottom, to 61° F. The temperature of this shaft, between 20 and 50 yards from the top, was pretty nearly the same as in the first-mentioned experiment. This is a hilly and otherwise uneven district. Some of the shafts open on the tops of those hills, while others are commenced at different elevations along the sides."

An experiment, perhaps still more valuable than any of the preceding, and for which he continues to express his particular obligation, was taken for him by Dr. Robertson and Mr. Shaw, both of Buxton, in "Poole's Hole," near that celebrated spa. This cave is entered through a low and narrow mouth at the foot of a small hill, which is steep and abrupt in its rise, and the summit of which, over the cave, having been a secondary lime-stone formation, has principally been torn away and burnt, and is succeeded by plantations of timber. The gentlemen found the temperature of the vacuity at 200 horizontal yards from the entrance, where it is spacious and high, to be 44°, that of the surrounding stone precisely corresponding; but the stream which rises in the cavern they found at 42°; thus confirming the author's own observations upon the cooling effect produced by the presence of water. They likewise learned from the guide that season affected the temperature little or none, and that the stream was then, (May 13, 1842,) "singularly low." Buxton being in latitude 52° 16′, this coolness is below theory, and Poole's Hole appears hence to be the Wielickza of England. It is a remarkable fact, that the constant temperature of the "gentlemen's bath" at Buxton is 82°.

The whole of these experiments distinctly prove that an "*invariable stratum*" of temperature, nearly identical with the medium of heat incidental to the latitude of locality, is every where to be found within a hundred feet of the earth's surface: hence, having clearly discovered the *locus* where Dame Nature will not distinguish between January and the Dog-days, we can here safely establish our place of business, and carry on the process of fermentation without hindrance. The worts having cooled as described in the two preceding chapters, and necessarily kept at an uniform temperature of from 45°

to 52°, or lower, the tun-room being constantly supplied by a running stream, and its air being influenced by the solid earthy bodies and exuding waters that surround it, every thing in contact with it or with the water, is kept at an uniform heat; the running waters must also surround every part of the fermenting mass except at the surface, and the vault must be made sufficiently capacious, *ab initio*, for that purpose: thus the natural propensity of the mass to advance in heat when fermenting, will be curbed; for these waters will be continually abstracting such extra heat as fast as it is generated, and will carry it away through a channel which must be made for that purpose; so that the fermenting liquor from the commencement to the end, can never exceed, under proper care, that one permanent heat. For this, various potential reasons may be assigned: 1. Saccharine liquors readily undergo the vinous fermentation unaided, at between 40° and 50°. 2. Alcohol, whether mixed with honey, or whether emanating from malt, or mixed with malt liquor, of which it is not native, requires heating to about 50° before it absorbs oxygen; and hence it is that we conclude, 3. That by keeping our extracts *below* the heat necessary for the combination of oxygen with alcohol, from the time that such extracts leave the coolers or refrigerator, through the full period occupied in their fermentation and during their storage, we shall, by the aid of experimental knowledge in other respects, effectually succeed in manufacturing from malt, hops, and water, with a little yeast if we please, a spirituous, permanent, brilliant, and sparkling *wine*, deserving the name of British Champagne, which will be capable, by due admixture, of improving every foreign wine brought into this country, and of superseding, in fact, if taken solely, except as regards the eccentricities of taste and tasters, even

the most notable of those wines, especially as it better suits the habitude and native powers of a constitution reared upon the same soil as the hardy elements from which such Champagne is to proceed. To such the Briton may comfortably say with Burns:—

> "Thou clears the head o' doited lear,
> Thou cheers the heart o' droopin' care,
> Thou strings the nerves o' labour fair
> A's weary toil.
> Thou even brightens dark despair
> Wi' gloomy smile."

For as violence in the fermentation will produce acidity, so gentleness will prevent it, and will even cause the *must*, for it cannot now longer be properly called *wort*, when arrived at this stage of its purification, to withstand the shocks of agitation. This has been fully exemplified in the durability of Bavarian beer and the practice of the Champagnois. To prevent disastrous consequences, then, the great object evidently is, to keep the temperature within restrained bounds, and in that focus the energies of the brewer's mind must now centre, and his apparatus must be adapted accordingly. In a tun-room, constructed as this chapter directs, the refrigerating water will have entirely left the fermenting lake before it touches the tinned pipes, which he recommends placing in conjunction with it when Masterman's apparatus is not employed, and which, for the sake of convenience, may lie under the floor of the waste-water channel and stores, and be so arranged that they may be easily, expeditiously, and thoroughly cleansed. On the wort being let into these pipes from the coolers, the acquired heat will be rapidly absorbed by the tubes and transmitted to the surrounding element; and as they must be made to extend to the fermenting vessels, into which they are to have an outlet,

the worts may be confined, if necessary, till they have acquired the lowest temperature which the water can impart; and that the desired coolness may be attained without risk, constant attendance, and the loss of time caused by negligence or other causes, a self-acting thermometer may be fixed upon the cooler, to raise a valve, and allow the worts to run off through the refrigerator, whenever it is cooled to such desired degree, and to close again when a hotter wort approaches. The chief efficiency of such an automaton depends upon the principle of the expansion and contraction of metals. The motion will be accelerated by means of compound levers, the last of them, to which the greatest traversing motion is given, to be attached to the valve on the upper end of the refrigerating pipe. A similar instrument to this was patented some years ago, as the invention of Mr. Ward, of Stratford-on-Avon, for ventilation and other purposes; but its application to the brewery, as here proposed, is a novelty. Dr. Ure invented a similar self-acting metallic instrument, which he calls a "Thermostadt," a full description of which is given in Hebert's Engineers' and Mechanics' Encyclopædia.

In order to make the *Constant Temperature Vault* still more perfect as a house of business, the author, in addition to the foregoing, would introduce an auxiliary to his other arrangements in the tun-room, the provision of a plan to neutralise superfluous heat at all times, which he has entitled,

The Caloriphagon.

This instrument takes its name from *calor*, heat, and *φαγω*, to eat or devour, and would perhaps with more strict classical propriety be termed the *thermophagon*, or *caloredant;* but signifies, at all events, the *heat-*

consumer. When any manual labour or other routine of business is to be performed in the subterranean square-room or stores, artificial light will of course be required; and since every precaution must be taken not to increase the temperature beyond the prescribed limits, that is, to prevent the smallest increase when the thermometer indicates 52°, a lamp of a peculiar construction, and, as far as the author's knowledge extends, perfectly novel, is provided for this purpose; by which it will be seen that every ray will be brought into useful play, without the usual heat accompanying the light. His plan is to envelope the whole light of the tun-room in water, for which purpose he provides three, four, or five glass cylinders, of different dimensions, so that one may go inside another, and every where leave a space of an inch or two between the interior surface of any one of them, and the convex outside of the next to it, the innermost or smallest containing the light, and the intermediate spaces between these several tubes being filled with cold water, that within the outermost or largest flowing round the next and over the edge of it; that of the second under the third, and so on successively, these waters gradually absorbing the heat in the order of their approximation to the centre, the innermost passing the water away through a metallic tube fixed in a dome above, which inner tube or pipe will convey off with the waters all the unconsumed carbon and effluvia of the lamp; for an unshielded light will transfer some of its caloric to the atmosphere through which it travels; that is, during the passage of its rays towards the reflectors, which should be a species of hemispheres, reflecting nearly the whole of the illuminating rays upon the objects requiring light. Each reflector should be made to work on an universal joint at

its back, with a tightening screw to fasten it in the position it is intended to occupy, in order to direct the cool rays to particular distant objects.

In the next place, the inventor recommends that the drippings of the arch or roof be received on a light curved shield, for which purpose an excellent material will be found in Taylor's patent corrugated metallic roofing, which, to be preserved from oxidation, should be galvanised according to Porter's or Morewood's new process of coating iron with zinc, or with a mixture of that and tin. This contrivance conveys the waters to each side of the room, whence they run under a raised and grated iron flooring, by which means the attemperating and refrigerating property of the waters is rendered available, without occasioning the slightest annoyance from moisture or damp; and although the natural temperature of places thus systematically selected for the new and improved kind of fermentation, will of itself in a great measure regulate the heat of the air within, the principle here devised contributes essentially to the comfort and convenience of the persons employed to conduct this department of the establishment. It also aids the general object by giving great security, and by checking the first and slightest attempt of the fermentation to increase its caloric beyond the standard employed, be it the all-sufficient 52° or otherwise; for as a current of air accompanies all running streams more or less, so will the motion caused by the numerous flowing waters in the vault, carry away all vapours that are emitted either by the fermenting vessels, or from the bodies of the workmen engaged in racking the "sovereign cordial," or cleaning the utensils.

CHAPTER XIII.

FERMENTS.

GENERAL PRINCIPLES—CAUTION—YEAST—BARM—THE FERMENTING IMPETUS AND VEHICLE—BRANDE'S LECTURES—DOCTRINES OF PHILOSOPHERS—THE YEAST-BITE — PROOF QUALITIES OF BARM — CURIOUS FACTS — BAVARIAN PROCESS—LYMPHINE FERMENTATION—FOWNES ON ARTIFICIAL FERMENTS —BOUCHARDAT'S NEW LIGHT.

FERMENTATION, according to Thomson, is a term which was first introduced into chemistry by Van Helmont; and he says that some suppose it to have had its origin in the intestine *motion* always perceptible when vegetable substances undergo it, and that others derive it from the *heat* thereby generated; but that it is now generally applied to all changes which vegetable bodies spontaneously make, with reference to results: it appears, nevertheless, to come from the Latin *fermento*, to puff up or render light; while its diminutive *fermentesco* represents the symptoms of rising or leavening.

Chemists differ in opinion upon the precise nature of this extraordinary process, and the number of its stages. In Chambers's Information for the People, Part XIII., p. 84, we are told that they reckon *five* distinct species, which are, the *saccharine*, which changes gum and starch into sugar; the *vinous*, which converts sugar into alcohol; the *acetous*, by which alcohol and other substances are turned into vinegar; the *mucilaginous*, producing slime from sugar, instead of alcohol; and the *putrid*, or decomposition of animal and vegetable sub-

stances. Of the first of these we have disposed already, and with the rest we have now to deal; and it becomes us to take care how we treat the subject, to secure the good and avoid the evil. There is, however, a sixth sort of fermentation, which does not concern the brewer except as to the disposal of his fermenting material, but is as old as the Levitical law: this is the *panary* process, by which the flour of corn is turned into dough for bread, when water and an exciting cause are added.

Thomson confines his term to *three* species, which he designates the *vinous*, the *acetous*, and the *putrefactive;* the first producing *spirit*, the second *vinegar*, and the third reducing the substance to *soil.* Liebig's denominations are similar, dividing his chemical transformations, by which "some of the elements decomposed are singly set at liberty," into *fermentation*, *putrefaction*, and *eremacausis* or *decay;* and says that they arise from a disturbance of the equilibrium, which causes the particles of the body moved to follow their natural attractions, or to obey other affinities. In this way he accounts for the progress of putrefaction and disease, whenever an affected particle touches those of the same species which are sane; and he conceives that in fermentation and putrefaction, the elements composing the organic substances separate themselves from the organism; and being exposed to the influence of *water* at a certain temperature, that they enter into new combinations in which the constituents of the water act; which kind of decomposition he terms a transformation; but that eremacausis (derivable from ερημοω, to separate, by καυσις, heat) requires an accession of *air*, from which the decaying body absorbs oxygen, and is a slow combustion, uniformly evolving heat and sometimes light. It has been very judiciously observed by the

intelligent, and amongst them by Thomson, that fermentation does not take place, except in vegetable substances containing water, at a temperature above the freezing point, which is the basis of an obvious mode of *preventing* it; and that furthermore the kind of fermenting termed *acetous*, is an example in which the alcohol absorbs oxygen at a particular temperature, and thereby becomes vinegar. In short, we find throughout nature, that heat is one of the principal agents in dividing, dissolving, and decomposing animal, vegetable, and mineral matter, and that solids become liquid, and liquids vapour or gases, in proportion to the quantity of heat present, or to some law dependent upon it. This principle exerts a powerful influence in fermentation, breaking through all the affinities and cohesions, and preparing new arrangements, simple or compound, in liquids or solids so separated; and these effects are dependent on the amount of caloric present, the commanding influence of which is much felt by the brewer in every stage of brewing, and in every department of the brewery, but especially in the fermenting room and stores; how necessary, then, to counteract its ravages!

The worts, at a proper degree of heat, evince an immediate symptom of change in the composition of their sugar and water, especially when induced by the presence of a fermenting medium, whether applied upon the coolers, or in the gyle-tun or vat. The operator must now bear in mind that the ferment called *barm* possesses a very strong affinity for oxygen, because of its strong inclination to decay, during which change oxygen is indispensable as a decomposing power; but whether the first parts of this element, thus appropriated, have been derived from the sweet principle of the wort by the ferment, so that its equilibrium

thereby becomes broken; or whether the ferment has previously imbibed enough from the air, and a similar state of decomposition has been entailed upon the sweet by the mere power of contagion, through transition to the contiguous fluid, is of little moment here. It is sufficient, that by the interposition of the ferment, the old affinities of the saccharine solution in contact are destroyed, and a speedy decomposition ensues, by which every original particle becomes affected. It is probable, that, under ordinary circumstances, various processes of fermentation go on in a gyle at the same time, in a greater or less degree; the putrefactive being excited by the glutinous substances, the gluten immediately engaging with it to alter the albuminous property, and so on in due rotation, till the particles least susceptible of decay yield to their influence. The decomposition of the sugar follows, and next in succession the mucilage; and if a large amount of caloric be present, such atoms of starch, hordein, &c., as remain, become subject to a similar change; and the more vigorous appearance of the fermentation is made evident when each of these several constituents is engaged in the same simultaneous and universal ruin. No other part of the extract than that which is constitutionally sweet, or has become so by a saccharising conversion, can produce alcohol; and it is the transformation of the saccharum into alcohol which is termed vinous fermentation. The acetous is already explained. The putrefactive is a dissolution of matter containing nitrogen, though the term is now rendered almost general, signifying the decomposition of all vegetable matter, in whatsoever form it happens. It shall be shewn that alcohol is the standard of qualification in vinous liquor, being, as it were, a fulcrum on which its perfection

depends. Add hydrogen, and it leans to ether; but if oxygen preponderate only an atom, it inclines to aldehyde; give it another, then the equipoise is irrecoverably lost, and it falls into acidity.

During the fermenting process, large quantities of carbonic acid gas and some hydrogen gas are formed at the expense of the carbon of the sweet, and the oxygen of either the solid or the liquid, or both, attended by an intestine motion, a slight noise, and an increase of temperature, if not duly curbed; and it is quite probable that on the old plan, the atmospheric air which has been regained upon the coolers after boiling, is first exhausted by the decomposing mass; and that afterwards, as the process goes on, the water is attacked, and its oxygen, as well as that of the atmospheric supply, becomes engaged to the same purpose; while the hydrogen, which must thereby necessarily be set free, is either assisting it in the formation of spirit, or flies off with the carbonic acid gas.

The solutions of all vegetable substances partaking of sweetness, and not having nitrogen in their constitution, such as crystallised cane sugar, starch sugar, and converted mucilage, require the addition of a substance partially composed of that essential element, before they will undergo the alcoholic or vinous fermentation. It is sufficient if they are in contact with either animal matter, or such vegetable substances as are termed the most *animalised*, such as albumen, gluten, and the like; and although these or similar nitrogenised matters need be in a decomposing state to qualify them for the office of exciting fermentation in saccharine fluids, such a condition needs not be an object of ardent solicitude by the brewer, since his ferment, as it consists principally of the natural diastatic albumen, associated

with the gluten of his grain, wants only oxygen, moisture, and an agreeable temperature, to proceed immediately to putrefaction.

Here be it observed, that *yeast* is not necessarily *barm*, or the *cerevisia fermentum*, but is an ancient English word, and takes its name from its property of *yearing*, or *working round* into its former condition; a property which those who have not inwardly *yearned* cannot duly appreciate. When, therefore, Ham emphatically says, "*Let no yeast be used*," he evidently only prohibits *barm* as a *species* of yeast; for to prohibit yeast in general, is to supersede working altogether. *Yeast*, no doubt, is from the same stock as ζεω (defined at p. 8), and is equally significant of agitation.

Though the author's experience teaches him to adopt Mr. Ham's advice to some extent, he is not quite so parsimonious as that writer, and much less is he so extravagant as Levesque, as he is satisfied that a careful accommodating *middle* course is the best. Barm can be used at pitching, or added from time to time as the fermentation proceeds, according to the judgment and experience of the brewer, or to the urgency of the case. The Young Brewer's Monitor gives the reason neatly thus:—"The fermentable matter of the malt and hops, although composed of several of the immediate principles of vegetables, consists of the elementary substances, combined in certain proportions, and held in equilibrium or reciprocal combination by their mutual powers of attraction. But as this vegetable compound, like all others capable of fermentation, is of a temporary and transient nature, the attraction which holds its principles combined is so weak, that a very slight force only is necessary to destroy it, nothing more being wanted than certain proportions of heat and moisture, which separate its particles beyond the sphere of attrac-

tion, diminish their primitive cohesion, and dispose them to act reciprocally on each other; and accordingly we find that if this vegetable compound or wort is kept at a sufficient temperature, it enters into a spontaneous fermentation. Here, however, as its progress would be slow and irregular, and its termination indefinite, we could not arrive at the desired point of decomposition before the acetous change would take place; we have, therefore, recourse to yeast, which destroys the equilibrium more speedily, and accelerates the decomposition." Under precautionary circumstances, that is, with duly attemperated worts, properly hopped and prudently cooled, and in a cave with plenty of square-room, or where the fermentation can be carried on above-ground in a steady atmosphere of from 40° to 50°, when spring-water is ready to be passed through fixed internal attemperators in common use about the same temperature, not more than *four ounces per barrel* can be at all necessary as the *maximum* at pitching, and none will be afterwards required.

The vinous, acetous, and putrefactive processes require three distinct ferments, each imbued with a different power to effect its separate purpose; or, in other words, a wort will partake of that species of fermentation more or less, which exists in the fermenting vehicle unemployed, and according to the particular stage of decomposition at which the majority of its parts have arrived. When such or a similar condition is imparted to the wort, the ascendency of any particular stage in the latter depends upon its purity, density, and heat, either to aid, retard, or neutralise the progress of that species of decay which may be paramount in the additional ferment at the time of pitching; yet it too often happens that the result proves that an improper selection has been made, or that the age or quality of the yeast has been over-

looked. The correctness of such a theory is evinced by the spontaneous production of alcohol, acetic acid, and humus, simultaneously or consecutively, under ordinary circumstances, in the musts of both fruit and grain, where artificial ferment is required to be used; and may be found on enquiry into the constitution of the ferment universally employed by the common brewer, the distiller, and the vinegar-maker, and by also observing the peculiar properties, affinities, and productions of each constituent during their decomposition and afterwards, as well as their influence when in contact with similar and even different elementary principles, in all their varied forms of arrangement.

The heterogeneous character of the excrementitious part of the brewer's wort, recognised as his ferment or barm, may be seen on referring to Westrumb's analysis, and which reduces to the following *per centage*:—Water 88·509, gluten 3·125, saccharum 2·051, mucilage 1·562, alcohol 1.562, extractive 0·781, lime 0·449, malic acid 0·293, carbonic acid 0·098, potash 0·085, acetic acid 0·065, with traces of phosphoric acid and silica towards the 1·420 unaccounted for. It is obvious from this analysis, that the mucilage of the malt had not all passed into a saccharine state, and that some of the minor ingredients were incidental to the soil; and the variety of acids shews that the analysed barm was not of the purest quality. Chemists do not consider all these ingredients to be essential; and Westrumb's experiments demonstrate that when this yeast is filtered, a matter containing the properties of gluten remains upon the filter; and that when this substance is removed, the yeast loses its property of exciting fermentation, but recovers its power when gluten is added: whence it becomes evident, that this glutinous substance is the essential constituent of

the ferment. Also, when common barm is preserved for some time in cylindrical glass vessels, a white matter like curd disengages itself and floats on the surface; and when skimmed off, the barm loses its exciting power. This substance is like gluten in some of its properties, but not in others; its colour being whiter, its elasticity less, and its particles less adhesive, and its dissolution in acids is readier. Thomson considers this to be "gluten somewhat altered, and much more disposed to decomposition;" that it is the real part of yeast which causes fermentation; that it existed in the raw grain; but that it was considerably modified by malting, and by other incidents which took place while the must was fermenting.

As this analysis was published in Crell's Annals as early as 1796, it is to be regretted that the world has not been favoured with something more recent and conclusive; for it appears that the learned professor selected such yeast for his experiments as was destitute of the hop, or that he overlooked its resin and oil, which must have existed in proportions sufficient to fill up the space unaccounted for in his *per centage*. It is obvious also, that the white substance which separated itself from the gluten, and without which the latter would not act, was the albumen of the seed, and contained the diastase, which, unless boiled to nullity, was not only the "real ferment," but the original agitator; though its presence may not be necessary where *gluten* exists, which appears to be analogous to it, though not precisely identical, being of itself an all-sufficient agent, though not so peremptory as diastase; neither is any other substance composed of the same elements, however proportioned.

Boussingault found the gluten of wheat to be com-

posed as follows (Ann. Chim. et de Phys. LXIII. 229. Thom. p. 684):—

Carbon . .	$8\frac{1}{2}$ atoms	$=6{\cdot}375$, or *per cent.*	$53{\cdot}75$
Hydrogen,	7	$=0{\cdot}875$	$7{\cdot}55$
Oxygen . .	3	$=3{\cdot}000$	$24{\cdot}20$
Azote . . .	1	$=1{\cdot}750$	$14{\cdot}50$
	$19\frac{1}{2}$	$12{\cdot}$	$100{\cdot}$

The gluten of raw wheat, however, is not so active or so soluble before germination; or, in other words, is not so susceptible of putrefaction or decomposition as that of germinated or malted wheat; and the same observation may be applied to that of other corn, as barley, for example. This important circumstance is attributable to the original decomposing power of vegetation on each constituent of the grain during the first efforts of its reorganisation through the peculiar agency of the diastase, which owes its animation to the same cause, and is designed for this especial purpose, and also for stimulating and aiding the process of regeneration. Fabroni found that wheat gluten as a ferment acted but imperfectly, but that its efficacy was much improved by adding tartar; and Thomson informs us that Bertholet repeated a like series of experiments with success, and ascribed the efficient power of the tartar to the property which it has of increasing the solubility of gluten.

In a lecture delivered by Professor Brande, at the Royal Institution, as recorded in the "Forceps," he demonstrated that the chemical action of fermentation could not take place in any body unless its composition contained nitrogen; and shewed that, on mixing a small quantity of barm with a solution of sugar and water, a change would thus ensue:—as sugar consists of

3 atoms each of carbon, hydrogen, and oxygen, a proportion of this carbon will unite with the oxygen under the influence of the barm, and will form carbonic acid, and the remainder will be converted into alcohol. In manufacturing wine, he shewed that yeast is unnecessary, because the sugar in the grape contains the principle; yet the grapes may be dried into raisins without change, on account of the imperviousness of the skin of the grape to air. Even in drying, water can pass, but not air; therefore, allowing the air to enter but for a moment, fermentation will result from its admittance. Liebig introduced into a vessel containing a solution of sugar and water, a smaller one covered with muslin, and having a false bottom, and placed some yeast in the small vessel, and shewed that fermentation had commenced here, but not in the larger; nor would it do so till the particles became sufficiently reduced to pass through the gauze, notwithstanding the free communication between them. Mr. Brande also proved that the presence of creosote or turpentine always stops the action of barm, and that boiling answers no other purpose than delaying this action, which after some time cannot be perceived.

According also to Liebig, a principal part of barm is "gluten, or the azotised matter of corn." He treats very lengthily on the subject, and admits it to be known that the formation of barm depends upon oxygen being accompanied by gluten in the act of decomposition, but that it has not been sufficiently ascertained whether this oxygen comes from the water, from the sugar, or from the gluten itself; nor whether it combines with the gluten in a direct capacity, or whether merely with its hydrogen, so as to form water. The first hypothesis he terms an oxidation of the gluten, and says that the transposition of the atoms of the sugar into alcohol and

carbonic acid, necessarily attends this oxidation, so that if one of them is arrested, the other must likewise cease. He will not admit that the yeast which rises to the surface of the liquid in fermentation arises from complete decomposition, but is gluten oxidised, and is still capable of being transformed anew, by a transposition of its constituent elements; and that by virtue of this condition, it possesses the power of exciting fermentation in a solution of sugar; and if gluten be present, the decomposing sugar occasions its conversion into fresh yeast, which gives to the former yeast the appearance of reproducing itself. This is all oxidised gluten in a putrefactive state, by means of which a like transposition is induced among the elements of the sugar.

The same author again explains, with greater minuteness than before, on the authority of Colin, that *yeast* or *ferment*, from possessing the power of causing fermentation in saccharine juices, has all the characters of a nitrogenous compound in the state of putrefaction or eremacausis; and, according to Thenard, it emits carbonic and other gases when kept under water, which have an offensive smell, and is eventually turned into a substance like old cheese; and when its own putrefaction is complete, it loses the power of fermenting other bodies. To sustain its fermenting properties, he conceives that the presence of water is found necessary, and its power to excite fermentation is diminished by simple pressure, and is, he says, quite destroyed by drying; but the author's experience does not lead him to that conclusion; though the rest is true, that "the temperature of boiling water destroys its action, as do also alcohol, common salt, excess of sugar, sulphurous acid, volatile oils, and all antiseptic substances."

Wigney, in his philosophical treatise on brewing, attributes the fermenting principle of yeast solely to its accom-

panying carbonic acid gas, and thinks that the glutinous substance is merely its vehicle. In his Cyclopædia, edited in 1838, we find him again professing the same opinion, and while admitting that this singular power belongs to the gluten of the yeast, he still asserts that the carbonic acid gas is indispensably requisite to commence the vinous fermentation: nay, he yet further assures his readers, that yeast deprived of this gas will not cause this kind of agitation, but will beget that of an acetous or a putrefactive character. Suffice it to say, that common practice and observation contradict this theory of his, as well as others of his doctrines, such as the *coagulation* of *mucilage* by boiling, reverted to at p. 300, and his ideas on water, on solution in the mash-tun, and the like, where he gives effects for causes, or confounds his ingredients. The doctrine asserted by the ingenious "Monitor" is quite at variance with the above, and deserves particular notice. This author, after noticing that every atmospheric change from cold to mild, excites additional attenuation, and causes the liquid to fret, because its particles are expanded by the rarefied air, and, through occupying larger space, ascend in the mass, and the generation of more heat and motion conduce to the acetous change; whereas in a good fermentation, properly conducted, the *progress and result* are, that the fermentable matter is reduced to its first principles, its particles are presented to each other in true chemical affinity, part being *resolved* into spirit, part *into fixed air*, and a small part, from being deprived of their elasticity, "*sink to rise no more.*" Carbonic acid gas is therefore not a cause, but an effect; and how is it produced?—"The oxygen, which is the most abundant principle, unites in new proportions with the other ingredients, part of it attaching itself to the hydrogen, and a small portion of the carbon forms alcohol, or

spirit, which a larger portion of the oxygen and carbon unites in *forming* carbonic acid gas, or fixed air, which rises from the body of the wort, and is that suffocating effluvium with which the brewer is so well acquainted." Monitor, p. 23.

Contrary to the assertions of some, common yeast will retain its decomposing quality a long while in a dry state, especially when the air is excluded; and it exercises the property of exciting the alcoholic fermentation after the evolution of *all* its carbonic acid gas by boiling, and even after the expulsion of its moisture by baking or roasting before the fire, because *its albumen is not destroyed.* The acidity, bitterness, or putrescence of the yeast so treated, requires no test beyond the senses, and the quantity of water that evaporates during the drying process is astonishing: indeed it appears that the water is increased for a time, by the union of oxygen and hydrogen, evolved by the rapid decomposition of the yeast during its exposure to such high heats. When dry, its colour is deepened, and its smell becomes rather offensive, but the bitterness is predominant, and almost absolute.

The extreme bitterness thus produced in the yeast, and the preservation of the decomposing property, led the author to reflect on the cause of the *yeast bite.* Yeast-bitten ales are seldom bright, which circumstance, and the cause of the very nauseous and rank flavour, have not been satisfactorily explained. Ham says that it never takes place except in beer undergoing violent fermentation; whereas Roberts attributes it to the inferior quality of the ferment used. These two opinions united may assist in solving the question, but are not sufficient in themselves to produce this objectionable property in an extreme degree; for it is seldom perceived till the attenuation is nearly over, and conse-

quently till a large amount of alcohol is present. The extreme putrefaction of certain vegetable substances, as bruised and mouldy malt for instance, or baked yeast, will produce an acrid bitterness. The most reasonable way to account for yeast-bitten beer, is to attribute it to a limited quantity of *emaciated yeast*, the bitter property of which is owing to its final decay and attendant high heats, and the bitterness is increased by the resin and tannin of the hop, operated upon by the alcohol and additional heat, which dissolve it with the humous-like gluten, and blend it with the beer. This bad and peculiar flavour is seldom if ever evinced by the distillers' wash, where hops are not used, although their heats are exceedingly high, and the quantity of yeast used during their fermentations is large, and often not of the freshest or soundest description. When this catastrophe takes place, not only are the heats higher than necessary, but the skimming has been neglected, and the head of the yeast has evidently fallen into the must, or has never stood upon its surface; for had the must supported a deep head, it would also have borne up the light hop-resin that accompanied it. The attendant cloudiness is attributable to the solution of the yeasty particles by the acetic acid, which acid is ever copiously formed during high fermentations. But the bitter impregnation is not by any means an instantaneous operation, nor is it entirely dependent upon the presence of bad yeast or high heats, as before observed; for it will take place to a moderate extent, excepting the dull appearance, with the best of yeast, and a temperature as low as 70°. In this case the head will be very shallow from the beginning of the fermentation to the end, and the escape of gases towards the close of the process will be both copious and tumultuous, the natural and artificial products being incorporated and actively engaged

with the whole body of the wort, instead of forming a hindrance to the free ingress of invited oxygen of the atmosphere, by covering its surface to an inconvenient depth; and here let it be noticed, that the deep and dense layer of carbonic acid gas does not appear in the least to impede its ingress. The attenuation will be much lower and more expeditious than usual, and will promptly supply the necessary amount of alcohol, and expose all the bitter principle of the hop to its influence; the whole of this latter process amounting to neither more nor less than an economical application of the hop, notwithstanding the apprehensions of the timid, and the mystifications of quackery in relation to this subject. By a right application of the attemperator, and a judicious selection of the ferment, that which is known as yeast-bitten beer can at all times be avoided, and the resin of the hop will be imparted to the article with considerable advantage.

The principal causes of a thin head of yeast, with large bubbles constantly forming and breaking on the surface of the fermenting wort, arise from the altered condition of the gluten, through improper mashing heats, and by the fire of the malt kiln, which has rendered the yeasty constituents less adhesive when surcharged and expanded by the rising carbonic acid gas. This objectionable character of fermentation may be prevented in future by the use of paler materials, or by adding a few quarters of pale malt to such grist as that which produced it; for the less malt is exposed to fire, the more tenacious and cohesive are its glutinous particles: this in a great measure accounts for the deep and accumulated head upon pale beer in an ordinary course of fermentation.

According to the constituents of yeast, as expounded above in the evidence of Westrumb, all compound yeast

placed in warmer situations than 52° is liable to all the singular and complicated metamorphoses to which vegetable solutions are subject. The nitrogenised solids are the only part of the brewer's ferment that is really useful; and they are the most so during its purest and primitive state. When exposed to the atmosphere, oxygen is absorbed so rapidly, that such solids not only weaken and perish by exhaustion, but the accompanying alcohol is speedily converted into an acid; and in proportion as acids exist in the ferment, so do they exercise a contaminating and acidulating influence, on the principle of contagion, over the newly generated alcohol of the must, particularly when the vinous fermentation is retarded by an undue share of mucilage, and a degeneracy in the artificial ferment. In such destructive changes the oxygen appears to be appropriated by the alcohol faster than by those principles of putrefaction, the glutinous compound, and the carbon of the saccharine matter. Writers may continue to call this an "acetous fermentation," but it appears more like an acetous *impregnation*, the motive power being vested in the putrefactive agent; therefore, by all means it is desirable to keep cool and stable.

When a brewer changes his locality, he will find that, as in the case of water, practice alone will put him right in the choice, quantity, and management of his yeast. The character of this stimulant varies as much as any thing in nature, depending on many circumstances, the most immediate of which are the time of its original production, its after treatment, its situation, and its age. Yeast cannot be too pure, energetic, fresh, and solid, for the brewer's use. The best is obtained from pale gyles that undergo the skimming process, a system of management but little known or practised in the provinces. The yeast to which the author finds preference

due, is that which accumulates on the surface of the musts at or near the close of their vinous fermentation. This owes the superiority of its nature to the period when it rises, and to being peculiarly exposed and yet in a protected situation, more than to any other combination of circumstances. It should be collected after the first or second skimming, and used as soon as possible, as much for its own unimpaired condition as for its perfect inability to impart too much of either oxygen or acid; and from the fact that this yeast and its fluids are less susceptible of the aceto-putrefactive decomposition, than that which preceded it, there is no doubt but that it is the last of its kind which separates from the mucilage during the close of the fermentation, and that it contains less of the old ferment and less albumen than any other; for the principal part of these either falls to the bottom or floats upwards before one-half of the attenuation is over: such yeast, then, is purer and more durable, glutinous, and energetic, because it has emanated from the last extract, and its desirability is enhanced by its freshness, and by the soundness insured by the constant imbibition of alcoholic and carbonaceous vapours imparted by its supporting parent, and amply remunerating this yeasty shield for its partial protection of the must from the air during the time of its accumulation. One pound of this yeast, if used in due time, will be equal to three or four pounds of such mixtures as are commonly used; and if this important commodity were more carefully selected, kept less fluid, in colder situations, and in vessels with hydraulic covers, and for much shorter periods than are usual, not only would a smaller quantity suffice, but less acidity would be imparted to the must, and the fermentations would be healthy and vigorous under low temperatures, and the dangerous and often futile prac-

tice of adding more yeast to stimulate the fermentation when near an imperfect close would never be required.

This subject has derived exceedingly little elucidation, and not much attention, from the gentlemen who have hitherto contributed to the brewer's library: the author observes, nevertheless, one writer recommending that yeast be exposed to the atmosphere a certain time, previously to being used for pitching, in order that it may become sufficiently decomposed to effect a prompter influence over the worts; but with due deference to such an opinion, which is that of Levesque, it may be asserted with safety that such intentional exposure is not only unnecessary but dangerous, especially during the warmer months of the year, as has already been explained. The present author has actually known the alcohol of an unfinished gyle of 36lbs. *per* barrel acetified by the addition of barm that has been too thoroughly oxidised, and even at a temperature of 71° in an atmosphere of 75°, and the attenuation about 18lbs., the fermentation having become languid, and appearing to require the aid of an additional stimulant; and it is not unlikely that inattention to this part of the process is frequently the main cause of the "out of order" state of some establishments in difficult seasons.

Yeast soon loses its power by repetition; so much so, that Richardson compares it to seed sown in the same field, which by a succession of sowings produces worse crops; and he relates the incident, that having one brewery at Hull and another at Beverley, he carried yeast from one to the other, when it would not work sufficiently in the place where it was produced, a circumstance which he attributed to the quality of the waters, one brewery being supplied by a well and the other from a river, because when the malt was the same in both breweries, the potency of the barm could not

diminish on that account. Many brewers of the present day entertain the like opinion, and frequently send from brewery to brewery to seek "a change of yeast," imagining, of course, that they can get from their neighbours some superior to their own; but all this risk, trouble, and expense, may be safely avoided, and the degeneration of their own yeast will be prevented by adopting the method of selecting the newly developed yeast originating directly from the last extract, and by the air-tight and cool means here recommended for its preservation Those brewers in the north who but partly ferment their ales on Mr. Bentley's improved system, often find that the greater part of the yeast derivable from such a process is unfit for fermentation, through the emaciated condition wrought by its repeated exposure to the air, and to its former peculiarly harassing vocation.

The quantity of ferment that may be requisite depends upon a variety of eircumstances, such as the quality of the water and of the grain, the pitching heat, the density, and other casualties; but the judgment of the brewer, founded on experience, must be exercised in this respect, no general rule being applicable to all cases; but at all events, the smaller the quantity that will efficaciously effect the purpose without exhaustion, the better for the produce. An idea of Liebig's may be interesting here: he says that the transformation of a certain quantity of sugar requires a certain quantity of yeast to effect it, not because quantity acts in increasing any affinity, but because its influence entirely depends upon its presence alone, which presence is necessary till the last atom of the sugar is decomposed; so that when the quantity of ferment is less than adequately small, it will complete its

own putrefaction before it can accomplish the transformation of all the sugar; but when the ferment predominates, a certain quantity of it remains as it was, when all the sugar has passed through the fermenting process; whence it will appear that the natural ferment is insufficient, though sparingly aided by the foreign supply. If, nevertheless, sufficient time could be allowed for carrying on the process under favourable circumstances, the constitutional ferment would be equal to the task; but this is generally impracticable in a wholesale establishment. Yet if we say that with all the skill that the advocates of barm and heat can command, the natural ferment is preferable in the abstract, to the most strictly available extent, because nature has adopted her own quanta of saccharum and albuminous gluten, one to the other, our observation will be indubitably correct when applied to the calm process, where the consumption of the azotised matter does not surpass the ratio of decomposition in the saccharum.

A brief description of a different kind of yeast is given by Liebig, who has discovered that the yeast which is formed by the fermentation of Bavarian beer is oxidised gluten in decay; and that the decomposition of its constituents gives rise to a very protracted fermentation in the sugar. So far is the intensity of the action lessened, that the gluten still held in solution by the fluid takes no part in it; for the fermenting sugar does not excite fermentation in the gluten, but the contact of the gluten or yeast already precipitated or decaying, produces an eremacausis of the gluten which the wort has dissolved, oxygen gas is drawn from the air, and all the gluten in solution is deposited as yeast, like a viscous sediment, on the bottom of the vessel. The carbonic acid gas which the fermentation evolves,

does not rise in large bubbles as in the ordinary course, but in myriads of *glomeramina*, similar to such as escape from a liquid saturated by high pressure.

This is the principle which distinguishes the Bavarian process from the common English mode. In the latter, a large quantity of yeast forms a thick scum on the surface, for because part of the sugar is employed in converting the ferment into gluten, the carbonic acid generated during the process attaches itself to the particles of the yeast, which thereby become specifically lighter than the liquid mass, and *rise to its surface.* Gluten in the act of oxidation, says the great chemist last named, comes in contact with the particles of sugar decomposing in the interior, on which the carbonic acid from the sugar, and the insoluble ferment from the gluten, are disengaged at the same time, and cohere to produce that effect; and as more gluten is employed than is necessary for the formation of alcohol, and has a strong disposition to attract oxygen, and thereby to anticipate its own decay, the great excess which remains undissolved in the fermented liquid when the transformation of the sugar has been completed, attacks the newly formed alcohol and turns it into acetic acid. But—"it is plain that with the separation of the gluten and that of all other substances capable of attracting oxygen, the beer would lose the property of becoming acid." Here the perfection of experimental knowledge has led to the solution of a most beautiful problem in the theory of fermentation; for this desirable riddance "is completely attained in the process of fermentation adopted in Bavaria;" for though both kinds of beer are completely saturated with carbonic acid when the fermentation ends, yet in Bavaria the extraction of oxygen by the gluten from part of the sugar *within*, in its conversion into ferment, is avoided by the introduction of oxygen *from*

without; and the eventual consequence is, that the action of the oxygen from the air, and the low temperature at which they ferment, cause the whole of the sugar to be transformed into alcohol; and this is especially the case whenever that transformation is unattended by the formation of ascending yeast: thus Bavarian beer contains more alcohol than that which is produced by ordinary fermentation, the quantities of malt being equal; for there the aërial oxygen does not unite with the alcohol, but with the gluten only, although it combines with both at higher temperatures, and forms acetic acid.

Dr. Ure, in the recently published Supplement to his Dictionary, remarks, that English, French, and most German beers "become gradually sour by contact of air," but that Bavarian may be preserved at pleasure, "without alteration in the air;" which quality is to be ascribed to the peculiar process termed by the Germans *untergährung*, or fermentation from below, who designate the superficial barm *oberhefe*, and the viscid sediment deposited at the bottom of the back by the Bavarian fermentation *unterhefe*. The top yeast being added to wort at a temperature from 46½° to 50° F., will produce a slow and quiet fermentation, accompanied by a "rising up" of the mass, while yeast collects both at the top and at the bottom; and if this deposit be removed for use in other operations, he observes that it gradually but slowly acquires the character of the *unterhefe*, and becomes incapable of exciting the phenomena of the "first fermentation" or *oberhefe*, causing only, at 59° F., those of the second or sedimentary fermentation. "The superficial yeast may be removed without stopping the fermentation, but the under-yeast cannot without arresting all the phenomena of disoxidation of the second period. These

would immediately cease; and if the temperature were now raised, they would be succeeded by the phenomena of the first period. The deposit does not excite the phenomena of tumultuous fermentation, for which reason it is totally unfit for *panification*, while the superficial yeast alone is suitable to this purpose." He wishes it to be carefully observed, that the proper *unterhefe* is quite different from the precipitate in backs ordinarily fermented, and urges the necessity of pains to obtain it genuine at the commencement, and in a proper condition for use. The Doctor compares the superficial yeast to vegetable matter putrefying in a marsh, and the sedimentary to the rotting of wood in *eremacausis*, which he calls "slow combustion;" but Liebig's comparison is much more elegant than this. Something more than art has led that distinguished analyst from an examination of the principles of fermentation, step by step, to contrast the two distinct modes of action and reproduction of ordinary and Bavarian yeast, or barm expelled into *oberhefe*, and yeast precipitated to become *unterhefe;* in the same manner that he would distinguish the contrary tantamount principles of small-pox virus and vaccine lymph. "Ordinary yeast and the virus of human small-pox effect a violent and tumultuous transformation; the former in vegetable juices, the latter in blood, in both which fluids respectively their constituents are contained, and they are reproduced from those fluids with all their characteristic properties. The precipitated yeast of Bavarian beer, on the other hand, acts entirely upon the sugar of the fermenting liquid, and occasions a very protracted decomposition of it, in which the gluten takes no part; but the air exercises an influence upon the latter substance, and causes it to assume a new form and nature, in consequence of

which this kind of yeast also is reproduced. The action of the virus of cow-pox is analogous to that of the low yeast; it communicates its own state of decomposition to a matter in the blood, and from a second matter is regenerated; but by a totally different mode of decomposition, the product possesses the mild form, and all the properties of the lymph of cow-pox." (P. 389, 2d edit.) This is an entirely new mode of "doctoring" beer, and is somewhat above art, for it is science in full sublimity, and leaves us without space to comment further on the subject, because it is desirable to lay before the reader the experiments and opinions of other talented chemists of the present day.

Artificial Ferments.—In the Mechanics' Magazine for August, 1844, is an excellent paper on this subject, by Dr. Fownes, who complains that bread raised by the old-fashioned dough "leaven" is always sour, and that a secret substitute is vended in the provinces; and he suggests, as a matter of great practical importance, the propriety of having the means to excite the vinous fermentation, when yeast of the ordinary kind cannot be obtained. He sees with Berzelius, that though much barm may be reproduced from a little, to create it anew is a difficult task, and refers to certain extraordinary phenomena to which that philosopher has applied the term "catalysis," which Liebig has assumed to explain on the principle of *induced* chemical action, and which MM. Boutron and Frémy have carried out in their researches on the formation of lactic acid, which go far to solve the difficulty. Diastase, in addition to converting starch into sugar, turns the sugar into lactic acid, and causes that acid to excite the vinous fermentation, whether fresh from the germinated grain, or advanced more or less towards putrefaction; he therefore mixes wheat flour and water

into a thick paste, which he exposes, slightly covered and in a warm situation, to spontaneous change, when it will undergo a series of transmutations resembling the several actions achieved by the diastase. About the third day of the exposure, he observes that it begins to emit a little gas, and to smell like stale milk; but this odour afterwards changes its character, the evolution of gas becomes much greater, and is attended by a new scent which is agreeably vinous. This, he says, will take place on the sixth or seventh day, "and the substance is then in a state to excite the alcoholic fermentation." The dough thus decomposed he mixes with a little tepid water, and applies it to a quantity of wort at 90° or 100° temperature, which he keeps up by placing the vessel in a warm situation, and in a few hours active fermentation begins, carbonic acid gas is disengaged in abundance, and when the action is complete, and the liquid clear, a quantity of excellent yeast is formed *underheft*, "well adapted to all purposes to which that substance is applicable."

In another experiment, he made a handful of flour into a thick paste with cold water, covered it with paper, and let it stand seven days on the mantelpiece of a room which had a fire all day, stirring the mixture occasionally; and at the end of that time he mashed three quarts of malt with two gallons of water, and added the paste as a ferment; the consequence of which was the production of a pint of thick barm, "which proved perfectly good for making bread," and a quantity of beer, "quite free from any unpleasant taste." These results led him to the conclusion, that common gluten of wheat resembles diastase in the manner of its decomposition, and runs like that substance through two successive dynamic stages, first into lactic acid, and next into alcoholic ferment; and he asks, in con-

clusion, whether it is too much to expect, that by proper means it might be detected in the third condition of a sugar ferment, acting like diastase itself as existing in malt. Diastase, he contends, has no more existence than yeast as a proximate principle; and his reasoning is just, as it is evident from the above that his paste undergoes a malting process, productive of the diastatic impetus: hence his argument that "its powers are purely dynamic, and that it is, in short, nothing more than the gluten of the seed in one of the earliest stages of its decomposition."

In recommending these experiments as models to country residents and colonial settlers, who wish to enjoy "the luxury of good bread," he suggests that they may manufacture a sufficiency of malt from any kind of grain, and that hops may *probably* be omitted when yeast alone is the required object. Of course they can, as the ferment is derived from the malt, and the bitter from the hop alone. Another part of his observation is worth recording, which is, that when wort, boiled and hopped, is set aside for spontaneous decomposition, its change is dependent on its strength, the weak requiring three or four days before any alteration is evinced, when a scum collects upon the surface, and precipitates a brown flocculent substance, incapable of exciting fermentation in sugar, the liquid emitting a flat offensive smell; whereas the strong becomes turbid from the separation of a yellow adhesive substance, emits gas slowly, creates alcohol, and deposits an active ferment to saccharine matter. He also notices, that in a moderately strong unboiled infusion of malt, and of course unhopped, acidity and turbidity suddenly commence after standing warm a few days; the progress in the change is rapid, carbonic acid is copiously evolved, and a thick insoluble whitish

matter settles down, which readily excites fermentation in a dilute solution of sugar, the supernatant liquid containing alcohol and acetic and lactic acids. He conceives that here, as before, the lactic acid is first formed, and that subsequently the vinous and acetous fermentations go on together.

NEW LIGHT ON THE GLOBULES OF FERMENTS.—M. Bouchardat, in a "Memoir on Alcoholic Ferments," published in the "Chemist," for September, 1844, distinguishes them as three separate species, which he terms *beer yeast*, *dregs yeast*, and *black yeast;* the first being collected in ordinary beer, the second in very strong, and the third in a deposit of white wine; and observes that each requires two kinds of nourishment to sustain it, namely, sugar, to produce heat by its "*dedoublement*," and nitrogenous matter, to furnish the elements appropriate for its assimilation and reproduction. He has elucidated, by means of the microscope, that the globules of all three are analogous to the nervous globules of superior animals; and that when "in definite conditions," they ramify and become transposed into vegetable infusoria, losing their character as ferments, from the spores of the new vegetation not possessing the property of decomposing the solution of sugar; but that their active nature, while unexhausted, resembles that of certain animal substances, and produces the same effects; as in the experiments by Colin, which proved the albumen of the egg to be an alcoholic ferment; and M. Bouchardat's own results shew that albumen, in contact with a saccharine solution at 92° F., converts into a ferment, the action of which is weak at the end of three weeks, but that the brains of a man become an energetic alcoholic ferment in 48 hours; and it is remarkable that similar con-

ditions apply to the three vegetable ferments before us, and that the substance composing the brain is formed by the union of globules of different kinds, of which the albuminous are among the most important, and these proteic globules are formed, like those of ferment, of an envelope insoluble in acidulated water, and of an enclosed albuminous matter soluble in such water, which is precisely the case with the globules of the vegetable ferments. Singularly enough, the brain of a young animal does not excite alcoholic fermentation, but is transformed into mucus, when put into a solution of sugar, and exposed to a temperature of 77°, because the envelopes have not sufficient resistance; and in like manner, though the "beer-yeast" will determine a brisk fermentation at a temperature varying between 50° and 84°, it terminates in a very few days, not being capable of exertion in liquors containing much alcohol, and consequently being speedily destroyed by the brisk fermentation; whereas the two other species determine slow fermentation at the same heat, the "dregs yeast" acting three or four months on liquors containing alcohol to the amount of 16 *per cent.*, without being sensibly destroyed, and the "black yeast" working six months under the same circumstances, and with the like result: all which experiments conduce to establish the natural fact, that as strength requires strength, so weakness can only be effectual when applied to weakness; which fact merits the brewer's observation.

The three ferments, though alike in some particulars, as in being albuminous compounds, containing oxygen, sulphur, and phosphorus; in being equally accessible to the removal of their lactic and phosphoric acids by alcohol, and of a fat liquid matter containing oleine, stearine, and an oil containing phosphorus, by ether;

and in being insoluble in pure water, or in water containing 0·001 of hydrochloric acid, though soluble in the latter after being bruised a long time with grains of silica, which is exactly the case with the adult grain; yet they differ from each other in form, colour, dimensions, and the contents of their globules, those of the *fermentum cerevisiæ* being seldom spherical, but generally spheroidal, like the albuminous globules of the brain; those of the *fermentum fœcis* more generally spherical, but sometimes ovoid; and those of the *fermentum nigrum* perfectly globular. The colour of the two first is uniformly whitish grey, but the globule of the third presents a very distinct black circle to the microscope, and the colour of the mass is uniformly a blackish grey. The diameter of the first species of globules M. B. estimates at $\frac{1}{91}$ to $\frac{1}{150}$ of a millemetre, and the greater number are well isolated asunder, though some have a smaller globule on the side, proceeding from the larger, and dependent on it, and sometimes united to it by an elongation: the diameter of the second species varies from $\frac{1}{314}$ to $\frac{1}{228}$ of a millemetre; almost all its globules are isolated, though some few have smaller dependents proceeding from the larger, in the same manner as the first; and the dimension of the third is $\frac{1}{248}$ to $\frac{1}{250}$ of a millemetre, and are all entirely isolated; for when they are collected, or have small globules attached, they are transformed, and lose their fermenting power; and note, 305 millemetres are an English foot. The contents of the first are granular, and those of the second lobulous; but the third are void, or at least they have no distinguishable interior parts.

The following are some of M. Bouchardat's experiments, with which this topic shall conclude:—

I. He took 25 grammes of a man's brain, weighing 14.1 drams avoirdupois, which he put into a quart of water, and added 250 grammes of sugar at a temperature of 77°, and in 48 hours the fermentation began and continued with regularity.

II. He dissolved the whites of four eggs and one kilogramme (2·206 lbs. avoirdupois) in four quarts of water, containing 0·001 of hydrochloric acid, filtered the liquors carefully, and put them in equal quantities into two flasks, adding an equally limpid solution of 10 grains of tannin in 100 grammes of water to the one, but nothing to the other. An abundant precipitate was immediately formed in the first, which, on exposure of 48 hours to a temperature of 77°, was partly converted into globules of $\frac{1}{400}$ millemetre, acting absolutely with the sugar, just like the *dreg* ferment; but the latter stood two months at temperatures varying from 59° to 77° F., without any manifestation of alcoholic change or of fermentation.

III. He took of sugar 1 kilogramme, water 4 quarts, yeast 50 grammes, white of egg, dissolved in water with the usual accompaniment of hydrochloric acid, 200 grammes, and maintained a temperature of 68°. The fermentation was promptly established, and continued regularly four days, when becoming slower, he collected his ferment, and found it to weigh 50½ grammes. He then repeated this experiment, substituting 100 grammes of fresh gluten for the albumen of the eggs; the fermentation went on four days as before, and only 49; grammes of ferment could be collected. From these results he concludes, that "the globules of the ferment do not assimilate more of the solution of sugar than the solutions of albumen and gluten," and asks, in conclusion, "Does it not follow that, if we find in the brewer's

vat 7 of ferment, when only 1 has been put in, it must be owing to this 1 part of ferment having met with proteic substances, which being placed in a fermenting medium, are proper for giving rise spontaneously to globules of ferment; the same as in the must of grape, *without* having added ferment, we find a considerable quantity of it?"

CHAPTER XIV.

ALCOHOL.

NAME AND CHARACTER—ALDEHYDE—PECULIAR ETHERS—THEORY RESPECTING THEM — STABILITY OF ALCOHOLIC STRENGTH — NON-ACETOUS ANTIDOTE—THE POTENTIAL FERMENTING SQUARE AND COVER—THEIR GREAT ADVANTAGES—SLATES AND SLABS— CEMENTS—CARBONIC ACID GAS—THE PNEUMATIC LIFE PROTECTOR.

NEXT to ferment is the alcohol that it produces, to the determination of which we now proceed, and to mark its properties. The external evidences of disorganisation, such as the hissing heard from within, and the decidedly perceptible motion, are in proportion to the liquidity, heat, and complex constitution of the decomposing body; but heat is the principal modifier of the whole process, whether it be supplied internally by chemical means, or externally by mechanical agency. As the fermentation of the must proceeds, its specific gravity becomes lighter, and it is now found to have acquired properties which it never before possessed, the most remarkable and most valuable of which is the *ethereal* part, which the ferment has formed from the hydrogen with some carbon and oxygen. The former rich body is now attenuated; the heat, if left uncurbed, has considerably increased; and the degree of attenuation has been provoked in accordance with such heat; and if the temperature be not checked by removing the ferment, by dividing and cooling, or by stopping the process through such other convenient means, the alco-

hol will begin to decay, because the second stage of fermentation will now set in, and convert the alcohol, by too great a diminution of its hydrogen, into aldehyde; a general and final dissolution will ensue; and the remnant will be no longer fit for animal consumption.

What, then, is alcohol?—and what is aldehyde?—and why is the one to be coveted, and the other renounced? According to Liebig, alcohol is a hydrate of ether; the latter being composed of $C^4. H^5. O.$, and the former of $C^4. H^5. O. + H. O.$: that is, ether contains

Carbon . . 4 atoms	=3.000,	or *per cent.*	64.865
Hydrogen, 5 . . .	=0.625	. . . .	13.513
Oxygen . . 1 . . .	=1.000	. . . .	21.622
	4.625		100.

But alcohol consists of

Carbon . . 4 atoms	=3.000,	or *per cent.*	52.174
Hydrogen, 5 . . .	=0.625	. . . .	10.870
Oxygen . . 1 . . .	=1.000	. . . .	17.391
Water . . . 1 . . .	=1.125	. . . .	19.565
	5.75		100.

Or, as the atom of water is compounded of an atom of oxygen with one of hydrogen, the real composition of alcohol is $C^4. H^6. O.^2$; that is, Carbon, *per cent.* as before, 52.174; Hydrogen, 13.044; and Oxygen, 34.782.

The signification of the word *alcohol* has been a matter in dispute. Some say that *al* is Arabic, and synonymous with *all;* as *alkoran*, the *whole code;* but we go no farther than the Greek, which gives αλκη or αλκα, *help* or *strength*, and ὁλος, the *whole;* wherefore alcohol contains the *whole virtue* of the wort or must. Here be it noted, as a contrast, that the advocates of total abstinence principles have recourse to bastard roots and an

offshot idiom, in order to carry out their measure by terrifying persons of the contrary persuasion to their own, deriving the word literally from αλκω, *to burn*, and ὁλως, in the *highest*, and telling us that, like eremacausis, it takes its name from its destructive qualities, as it might with some degree of truth be said to do, were the premises correct, or were it obtained, like spirituous liquors, by distillation only. It is probable hence that they mistake alcohol for aldehyde, which is constituted of $C.^4\ H.^3\ O. + H.\ O.$; that is, alcohol coerced out of two atoms of its hydrogen, by which means it is reduced to carbon *per cent.* 54.545, hydrogen 9.091, oxygen 36.364; and it is this subtraction of hydrogen which induces its tendency to become acid, and to perish in that state. This substance, according to Thomson, has a peculiar ethereal and penetrating odour. "When we draw this vapour into the lungs, we lose the power of breathing air. It produces a kind of cramp in the stomach." It has moreover this property, that "when kept in a vessel full of air, it absorbs oxygen, and is gradually converted into very concentrated acetic acid." (Org. Chem. p. 302.) It therefore exchanges its water for two atoms of oxygen, because acetic acid is $C.^4\ H.^3 O^3$, or C. and O. each 47.059, H. 5.882 *per cent.* The brewer will therefore do well to judge whether he will preserve his alcohol, or permit it, by over-fermenting, to run into aldehyde.

The etymology of *aldehyde*, as derived by Thomson, is a contraction of *alcohol dehydratus*, and such, as shewn above, is its character; and Liebig also says that aldehyde is alcohol *minus* hydrogen, acetic acid being formed by the direct union of aldehyde with oxygen. Alcohol, therefore, is the product of *vinous* fermentation, and *aldehyde* of a tendency to the *acetous*. Again, then, let the brewer discriminate within himself upon

the course which he must pursue to obtain the one, and eschew the other. All things combine in one general warning voice to him, not to permit his fermentations to rise above 50° or 52° ; because any excess above this heat, as declared in Chap. X., p. 320, attacks the alcohol and weakens its powers, if its existence is not altogether destroyed: indeed, it is a plain and simple fact, that the higher the temperature the greater is the absorption of oxygen and the loss of hydrogen. It is true from experience that malt liquors fermented by artificial means at 45°, in an ordinary summer atmosphere of 70°, will become acid sooner than if fermented at 65° or 70°; which once again testifies to the fact, that high temperature is not the *sole* cause of destruction to the alcohol; and though the Cambridgeshire ales, which are wrought at 80° to 100°, will keep fresh and sound in a temperature of 40°, nearly as long as those fermented at lower heats, yet there will be a striking difference in flavour and strength. Forlow's heady college ale was thus prepared. It is probable that in such cases the alcohol has assumed the property of aldehyde, and that a change only is wanted to bring on the acetous fermentation. Labouring men who are accustomed to beers fermented at these high heats, may perhaps prefer them to lighter and better; for that some of them are bright enough, must be allowed, and they are inured to their fare by habit; but woe to the stranger who partakes of them! Their effect upon his frame is a prostration of his mental and physical powers, and an attack of stupor, sleepiness, dulness, depression of spirits, and not unlikely headache; all caused by an inclination to aldehyde in the body of the beer.

The circumstance of a hot atmosphere in contiguity with must at a low heat, as 45° for instance, precludes the possibility of bestowing that time upon it which

gentle fermentation necessarily requires; but in this case, though the absorption of oxygen by the must may not create apparent injury, yet the rapidity with which the rarefied air absorbs the alcohol, at once interposes an obstacle not easily to be overcome. It is not necessary that the spirit should be rarefied in the cool must, except at its very surface, to enable it to ascend; but there is an affinity between such hot atmosphere and the spirit and gases, which causes them to unite by evaporation; and this volatility is urged onward by the escape of gases newly formed; but the propulsion and evaporation in a colder atmosphere do not affect the alcoholic principles to any serious extent, which again exhibits the necessity of a cool situation where to conduct the low species of fermentation. In the next place, though ales fermented under 50° in a corresponding temperature, may be in part subject to the ill effects of heat on being removed into a hot atmosphere, yet the heat will not be so decidedly felt as to cause acetification, because the absorber of the decaying element is not present to so large an extent, it having been purged downward during a lower, and therefore a more congenial, more perfect, and more conclusive attenuation; and if the species here advocated be conducted wisely, or to its fullest extent, so that the liquor may not exceed the specific gravity of foreign wines, it will keep in a pure, fresh, and wholesome condition in any atmosphere, equally with any of those wines. The low specific gravity of such wines as are brought to this country is generally in a great measure owing to the fictitious alcohol added before shipment, and often amounting to 25 *per cent.;* so that we cannot expect to attenuate down to them in any convenient duration of time; neither would that improve the beer in the estimation of Englishmen by being attenuated so low. Spanish

and Portuguese wines do not contain less than from 20 to 30 *per cent.* of alcohol; but the strongest English ale, if genuine, does not exceed 10 *per cent.* of that stimulant.

If malt liquor be fermented uniformly at 45° by the intervention of the attemperating quality of cold water, in an atmosphere as high as 70°, it will not be so gaseous as that fermented and kept at 45°, because the thirsty hot air, hovering so long over the must, has decomposed or carried off the spirit nearest the surface; and as fast as one stratum is destroyed or evaporated, another takes its place and meets with the same fate. These arguments shew that low heats are safe, whereas a high or fluctuating temperature is uncertain, and generally dangerous; for aldehyde itself, the principle to be avoided, would boil at 71¼°, if separated from the nutrimental and more voluminous fluid composing the beer, and is so readily reducible, that if but a *minum* of it be dropped into a vessel filled with moist air, the smell of acetic acid is directly perceptible. (Org. Chem. p. 302.) The degeneracy of alcohol into aldehyde, and thence into acetic acid, will be found more fully commented upon in Chap. XVI., where the next matter under consideration is brought into view to shew the relationship that obtains among them. The author has for a considerable period entertained the idea that malt liquors do not depend for their exciting powers upon the liquid alcohol alone, but that some other property yet unaccounted for exists within them, and this he ventures to call an ether; and the following circumstances tend to corroborate the idea of its existence in the generality of liquors.

Firstly.—Although as much rectified spirit as a pint of beer will yield, be added to as much water, with a portion of sugar and carbonic acid gas, as will together

refill the measure, and this mixture be close stopped and kept some days, so that the contraction and combination of the ingredients may be complete; the compound will not affect the animal system in the same degree as a pint of original beer containing the same quantity of each.

Secondly.—Old bottled ale, or such as is in good condition in the wood, or is copiously charged with carbonic and other native gases, excites the circulation and the nervous system, and causes the flow of the animal spirits to become freer and more spontaneous than can be done by new beer.

Thirdly.—That this secondary stimulant is composed of an ethereal fluid, is an argument that is strongly supported by a phenomenon with which grain distillers are well acquainted, called "blowing off," and which occurs thus:—Immediately before the weak foul liquid called "singlings" comes over by issuing from the lower end of the condensing worm, some incondensable gases of a very strong and intoxicating nature rush out of the worm. These are clearly distinguishable from carbonic acid gas by their extreme lightness and spirituosity; and as the gases, as well as the liquids that pass through the condenser, are equally temperate, we may infer from the specific gravity of carbonic acid gas, that a great part of it would flow down the worm as soon as it left the boiling wash, and parted with its caloric; but not so the ether; for though it left the hot wash even before the carbonic acid gas, its specific gravity would prevent its sinking through the air contained in the worm, till forced out by the accumulation of alcoholic vapour: hence arrives the period of this said "blowing off."

Fourthly.—During the ordinary fermentation of brewers' worts, a portion of each of the elements that contri-

bute to the formation of sugar, gluten, and even water, is emitted from the tun in a gaseous state, the largest portion being of a carbonaceous and acid nature, and the smallest and lightest hydrogenous, but uninflammable. On the other hand, if the decomposition is effected at high temperatures, carburetted hydrogen is evolved in such extraordinary quantities as to be inflammable on coming in contact with a burning light, and is extinguished only by excluding the atmospheric air; and it is notorious, as before seen from other premises, that the higher the heats of fermenting bodies, the more hydrogen they emit; but whether it emanates directly from the decomposed sugar, which is probable, or from a secondary condition from decomposed alcohol, has not been positively defined; but in either case the waste of strength is evident as an evil. Of this, see more in Chap. XVI.

Fifthly.—It appears hence that an ether is formed at the expense of the alcohol, as indeed all manipulated ethereals are. Common ether boils at 98°; its specific gravity, as compared with atmospheric air, is as 258 to 100; so that it is, like aldehyde, readily formed, and as easily lost in warm situations. The temperature at which malt liquors are usually fermented and stored is not so low as to prevent such a metamorphosis of the alcohol as this; and hence the natural consequence of the existence of this ether.

Sixthly.—A dewlike and tasteless moisture is often observed in the interior of the upper parts of fermenting vessels, and sometimes runs copiously over the edges of the barm boards, and down the outsides. There are two ways of accounting for this watery appearance. 1. According to modern science, alcohol being considered a hydrate of ether, this moisture may consist of some of the surplus water which is set free upon the

conversion of some of the alcohol or ether, and which water, from its extreme purity, comes in contact with the escaping ether, and by the velocity of its exit is brought over by that mere mechanical contact, rather than by chemical affinity, and condenses on meeting with a colder medium. 2. If not more truly, certainly more plausibly, the water may escape from the fermenting gyle with the carbonic acid gas by ordinary evaporation; the carbonic acid gas, hydrogen, and ethers, in each case, being incondensable by cold, making their escape invisibly, except as to the sense of taste; and in this way we may account for the Frenchman's patent mode of fermentation having failed, where, by means of close tuns and condensers, he sought to arrest the volatile spirit, and again to impregnate the must with it.

The action of this ether upon the senses may well lead us to presume that it slightly partakes of an oily as well as an acid character; but these properties are more odoriferous than spirituous or inebriating. Old vatted ales, strong with age, such as were not attenuated beyond one half of their original gravity previously to vatting, and have consequently undergone a long spontaneous decomposition while in a store of moderate temperature, ranging from 50° to 60°, possess this peculiar and agreeable but insinuating strength in high and rather permanent perfection; and if either carbonic or acetic acid is necessary, by combining with the alcohol, which is more than probable, such an article will always afford an ample supply to produce ether in abundance; for chemists can obtain either by distilling a mixture of alcohol and acid. Indeed the older good sound malt liquors are, the more of this ethereal strength they contain; and so valuable is its presence, that it compensates for the time and capital absorbed during its storage, either by yielding a better price in the market

than new ales of the same original density, or by being brewed some pounds *per* barrel lighter, and sold at the same price as the heavier bodied fetch. Again, if the first attenuation of such keeping ales were conducted to a somewhat low degree; as for example, if a 34 or 36 lbs. wort were reduced to 5 or 7 lbs. before vatting, and subjected with regard to situation and time to the like treatment with that which at first is less attenuated; it will in reality be stronger after a lapse of time, and its effects on the system will be more durable; though since its spirituosity is less volatile, its features will not be so striking, or so instantaneously evident to the senses. In each case the decomposition continues almost imperceptibly, but the strength and wholesomeness of the deeply attenuated ale increases much more abundantly than the other; yet it is exceedingly questionable whether the real alcohol increases much, and whether it fully retains its original character: indeed, it is stated to be an assertion made by Bouillon-la-Grange, (Jour. de Phys XXIX. 6.) that *when wine is distilled new, it yields more alcohol than if allowed to become old;* which change of condition, independently of the hypothetical evidence adduced, substantiates the ethereal theory.

But the question for present consideration is this:— Will ales that are fermented at between 40° and 50°, and that are continually kept in a store of equivalent temperature, possess the new ether under contemplation? For if they do not, we gain less by the storage under this circumstance than others, because the alcohol does not decompose; but if they may contain less ether, they then possess much more alcohol.

Now, notwithstanding the great varieties of ethers and ethereals already discovered and defined by chemists, and Dr. Turner's observation, that "no depart-

ment of organic chemistry has been so thoroughly investigated as that of the ethereal compounds;" here is at least one that has been nameless, but which may be entitled the *demeteric*, from **Δημητηρ**, a title given by lexicographers to Ceres, the goddess of Corn, derived from **γη**, the earth, and *μητηρ*, mother; and it may appear wonderful that the subject did not claim the attention of either chemist or brewer till noticed by the present author in his first edition. He hopes, since he has removed the ice from this depôt, that some abler advocate of the cause will, on finding the theory correct, shed a greater and more satisfactory light on a subject so interesting and important.

The increase in value of old ales during their storage, is probably derived from an evolution of alcohol and acetic acid while the ale remains in quiescence, and they undergo an undisturbed affinity, by means of which they etherise The existence of an ether in all ordinary fermented and stored liquors is inevitable, because the heat at which they are fermented is favourable to the formation of acid and the disengagement of a volatile spirit therewith connected. First-rate summer brewed ales, prepared for immediate consumption, with the advantages derivable from refrigerators, attemperated, and hard water, such as easily brighten, evince their decay ambiguously, though in warm situations; and ultimately in a peculiarly mild species of acidity, partaking more of hardness than of tartness, and for a considerable time preceding that of a more positive character; and while kept stationary in this condition, the ale retains its brilliancy several months, though otherwise under many local disadvantages; yet it decays gradually, and in some instances with such obliquity as to produce innoxious effects, with little deterioration of the genial strength; the principal cause of

which is, that the remaining yeast being precipitated and kept dormant in the mass by the intervention of natural and adventitious means, it does not acquire an atmospheric supply sufficient to produce an immediate and radical change in the constitution of the liquor. These circumstances have led the author to conclude that little besides the lightest and most susceptible of the spirituous parts of the liquor are subject to the decomposing influence of the absorbed oxygen, and the evaporative powers of a hot atmosphere; for although the ordinary fermented ales, however new, are never devoid of some little acid; and imagining inferentially that some acid is necessary to the formation of this singular ether; yet we may presume that an additional supply of oxygen is required, that even this mild acid may be evident to the palate. When the appearance of the liquid is otherwise than brilliant, and its turbidity is occasioned by the suspension of decomposing matter, the avidity with which large quantities of oxygen are imbibed or imparted during decomposition, actually and immediately diminishes the amount of alcohol; and being aided by a favouring heat, it ultimately transposes the whole, by creating a sharp sour acid of intolerable strength, be it aldehyde, be it acetic acid, or be it whatever it otherwise can.

All fermented liquors necessarily contain alcohol; and this product, as its definition imports, gives the liquor strength, and preserves the sweet and flavour; but as soon as this alcohol combines with oxygen, the transmutation weakens the beverage, and it becomes sour by the formation of aldehyde, and subsequently of acetic acid, at the expense of the alcohol; but by the more gentle process of fermentation, such a ruinous result is entirely avoided. Liebig attaches much weight to the free admission of mild air, arguing that when

the power of attraction in gluten over oxygen is increased by contact with precipitated yeast, in a decaying state, nothing more is necessary to its own conversion or oxidation into the same state, than the unrestrained access of air. Upon this indubitable circumstance, as upon an indestructible basis, he builds his "solution of one of the most beautiful problems of the theory of fermentation;" namely, that at a low temperature of less than 50°, the efforts of gluten and free oxygen cannot affect the newly formed alcohol, so as to produce eremacausis; that this low temperature therefore retards or resists the *combustion* of the alcohol, which would necessarily ensue if greater heat were applied. The great man last named advances a doctrine which may well be depended upon, where he says that alcohol undergoes no change at low temperatures, but is in the same state from its contact with oxidating gluten, in which the gluten of wine is placed by the addition of sulphurous acid; the oxygen of the air uniting with acid in one case and with the gluten in the other, without touching the gluten in the wine or the alcohol in the beer, though it would unite with both the gluten and the alcohol of the wine if the acid were absent, and would combine with the alcohol of the ale at higher temperatures, and turn it into acetic acid; for while kept low as in the Bavarian process, the free access of air separates from the beer every substance capable of decay, and the removal of this matter lessens the tendency of the beer to become acescent.

These principles, the author can aver, were seen and appreciated by him, though without a clear conception of the causes, at least seven years before he heard of Liebig's name; and although the theory may be for a while opposed by such as choose to maintain that no atmospheric air can pass through the very dense layer

of carbonic acid gas always resting on the face of the fermenting fluid, and continually making egress from all its parts, they should know that Dr. Hales found in the course of his experimental enquiries, that the extract of grapes absorbed one-third of its bulk of that compound element during fermentation, and that malt liquors imbibed one-fifth while under the like process. With what consistency, then, can men who deny this absorption of oxygen, rouse in the yeasty head in order to stimulate languid fermentation, or to re-excite its energies at the cleansing point? They know by experience that such a practice generally answers their purpose; for had not the floating yeast actually absorbed a large quantity of atmospheric air, or of its oxygen, it would not have been in a condition sufficiently decomposed and decomposing to perform the functions of a ferment so promptly. The fact of itself negatives the error, that a fermenting wort is rendered impervious to the oxygen of the air by the interposition of a denser gas.

A word more on the low fermentation termed sluggish, which is commonly the effect of stale yeast and long boiling, and is neither natural nor wholesome, but a condition to which mashing at an improper heat likewise contributes not a little. The fermentation of liquor thus mismanaged is never complete, but leaves it in that drowsy state so accurately described by Pope, where he says,

> " Flow, Welsted, flow, like thine inspirer, beer;
> Though stale, not ripe; though thin, yet never clear;
> So sweetly mawkish, and so smoothly dull,
> Heady, not strong; and foaming, though not full."

Having now pointed out the advantages of a well-conducted and vigorous but steady fermentation, and

some of the disadvantages of deviation into an extreme path on either hand, it will be proper, in the next place, to treat of fermenting vessels, as a subject of greater commercial importance in point of economy as well as appropriateness, than some have been disposed to imagine.

In economising space, and in facility of construction, squares are superior to rounds, at all times and places where minerals can be employed without being dearly bought; but when made of wood, rounds have the advantage in cleanliness and strength by having fewer angles to interrupt the cleaning, and by being bound with iron hoops, which are preferable to the nails that fasten the corners of squares; as the latter corrode and cause the vessels to leak, and finally to perish. Minerals, however, are better than wood in the abstract, for the reasons advanced in the tenth chapter above, when treating of coolers; hence, in all localities that will admit of the introduction, the author recommends, as a safe and economical utensil,

The Potential Fermenting Square.

The Constant Temperature Vault, or fermenting-room, should be so planted, that the fermenting vessels resemble so many islands placed in the middle of a lake or reservoir of the running water supplied from the crevices of the roof or ceiling, or from the sides and natural floor, in the form of springs, or by artificial conveyances; and the lake should be bounded by a low partition erected in front of the squares, separating them from the stores, and so properly elevated that they would be constantly immersed in water to within a few inches of their brims, and that when the lake is brought to that altitude, the superfluous water would flow over the edge of the partition.

In tun-rooms situated on level plains, where no fall or flowing can be obtained for the accumulated waters, and also where the expense of removing present establishments is an obstacle in the way of business, in order that their occupiers may, like the inhabitants of Scotland, Wales, Derbyshire, &c., "call spirits from the vasty deep," recourse must be had to the usual means adopted in mines of copper, iron, lead, coal, and such like, for effecting this object, as air or water pumps, or other available engines; and the lower extremities of the conducting tubes of these contrivances, must be inserted into large reservoirs or wells, situated in the lowest part of the subterraneous receptacle, and made expressly capacious for the purpose of accumulating such waters, and the carbonic acid gas, as the latter issues from the fermenting vessels. The prime mover of the brewing apparatus above ground should be applicable to this work.

Now, if philosophers maintain the axiom which says, "that distiller is the most skilful who can separate the largest quantity of alcohol at the least expense, and without imparting any disagreeable flavour," the author may be allowed to ascribe, without arrogance, some degree of credit to himself, if in *his* capacity he can preserve *his* alcohol in any eminent degree, without the impossibility of "smatching" the flavour by contact with wood, or metal, or atmosphere. With this view he has introduced his subterraneous tun-room as a standard admitting of perfection; for it is the want of substantiality and of regularity in the local plant of the fermenting vessels, as well as of management, that causes the encouragement given to the importation of paltry foreign wines, and the home consumption of wines that are falsely *called* foreign, such fictitious and low-priced rubbish, though far from *cheap*, having fine delusive

foreign names given to it, all of which kinds of trash, whether British or foreign, are as inferior to our own genuine and scientifically brewed "national beverage," in their nourishing, cheering, and invigorating qualities, as they are superior to common pop or lemonade; and the antidotal salvator, to produce and sustain the "*quant. suf.*" of alcoholic and durable life, is the "POTENTIAL FERMENTING SQUARE;" a vessel made of slate or flag, and for the following reasons:

I. ITS PECULIAR FORMATION. One of the most remarkable properties of this mineral is its cleavage; a quality which preserves to it two parallel smooth surfaces, the porosity of which decreases in proportion to its density; for it is a property of all bodies of a similar kind, that the denser the species, the less permeable is it to foreign intrusion. The heavier kinds must be the best, as drawing slate, for instance, is too brittle, too unctuous, too porous, and, of course, too light, when a more durable kind can be procured; and common mica slate, though exceedingly useful on light roofs, where it will lie for centuries and be little impaired, is yet too delicate in texture for the purpose in view. The specific gravity of the best drawing slate is not more than about 2,110, whereas that of mica ranges from 2,650 to 2,930.

The attention of the author having been called to investigate this subject, he has made enquiries at many different quarries respecting price and quality. Gwanas, near Dolgelly, produces a beautiful clear and cheap slate, but has not at present displayed masses sufficiently large for this purpose, as he would recommend that it be sawn into pieces 10 or 12 feet long, 5 or 6 wide, and from 2 to 3 inches thick, according to surface. One practical gentleman of his acquaintance advises the use of squares measuring 10 feet each way, and 5 or 6

feet deep, which dimensions will include a capacity of 500 or 600 cubic feet, or from 3000 to 4000 imperial gallons each; but this must depend upon the magnitude of the establishment, and other local circumstances. Of this size a very useful specimen will be found in the "Bangor Quarry Slab:" that obtained from the island of Valencia, on the coast of Ireland, is by some preferred to any other for its polish, density, and cheapness, but is liable to scale; and that obtained from Delabole, in Cornwall, is a tolerable article, but not so fine as the Bangor; but perhaps each will be preferred to the others by persons living in their respective vicinities, through the saving in carriage, which, if they be sent to any great distance, raises the price so considerably as to become an object with the purchaser. 100 barrels fill a cube of 100 inches, and 500 barrels one of 171 inches each dimension.

II. The simplicity of form in its construction. The ease with which slate cuts into longitudinal and latitudinal sections, naturally straight and not liable to warp, is a great merit; and they may be made to fit the room in which they are placed, without any waste of space, and may be fixed together by any of the cements known to practical mechanics, aided by bolts and nuts.

Let us next consider that of transplanting, by one operation, into one vessel, all the hitherto various processes of fermenting, cleansing, purifying, racking, and occasional minor trouble; for as soon as the subject brightens, which it will do in a few days by the new process, in the same square into which it was pitched, it is racked directly into the store or other casks, and is at once fit for sale or consumption. By almost every other plan of fermentation a large quantity of the liquor is wasted by being absorbed by the many vessels used, or through adhering to them, such as smaller

squares, tun-barrels, pontoes, cleansing casks, stillions, settling backs, tubs and pails, filling-up kettles, expensive self-acting apparatus, and parachutes; to say nothing of the splashings, slops, residues in every cask and vessel, and the loss by filling up, besides the accidents that may happen in some of so many transportations, nor of the continuous and extensive surfaces formed upon the yet embryo nectar by those various locations, and the consequent increase of evaporation of the volatile principles, upon which the strength and good quality of the liquor mainly depend; moreover, those multiplied processes convert the remnant, more or less, into a flat, foul-flavoured, and acetified drink; and it must yet be further considered that the liquor thrown off with the yeast in the ordinary processes trickles down the spouts and sides of the cleansing casks in thin streams or films, and that every available drop so unwisely exposed to oxygen, yeast, and corrupt matter, and so often returned into the fermenting vessel, to work over again only to be replaced, usually amounts, during such wasteful and protracted processes, to about an eighth of the whole gyle! These, with many other thoughtless proceedings already named, fully account for the immense quantities of sour and undrinkable ale daily seen or heard of, with pain to the brewer and grief to his customers.

III. *A few of the minor benefits* accruing from the subterraneous process, are the immediately intimate and certain incorporation of the hop, and the assurance that the whole of the essential oil (if not already boiled away), with the resinous and other antiseptic qualities, are permanently fixed in the liquor after it becomes bright, thus considerably economising this costly flower. The extreme bitterness of common yeast is evidence of a waste of hop, which cannot escape the notice of the

most casual observer. The most skilful and circumspect of good housekeepers prefer the barm of weak ales to use as a leaven, for the sole reason that it is less bitter, provided that it be fresh; but this bitterness betrays an evident waste of the hop; the yeast, therefore, which they most dislike is that which the carbonic acid gas has succeeded in floating out of the fermenting vessel from the stronger and better musts, which, as is well known, contain the most essential oil and resin; these valuable constituents are therefore thrown away; but in the fermentation which precipitates the yeast, they form a portion of the beer.

Each fermenting square may be provided with a loose metallic cover, having a rim sufficiently deep to enter the water at least half an inch; so that, when put on, and in its proper place, the fermenting fluid will be kept air-tight by such hydraulic valve cover, or sufficiently so to prevent an excess of air; whence, if any external air is required by the decomposing fluid, it will be equivalent to the task of drawing it through the water, and under this cover rim; but such an absorption of air cannot occur, except on the formation of a vacuum, and at such times as when the expansive force of the increasing and compressed carbonic acid gas is greater than the weight of this short column of water, since as much gas will ooze out through the water as will restore the equilibrium. But this seldom occurs where the surrounding stream descends with any rapidity, because the water is ever absorbing the gas as it falls upon the surface, and is conveying it away down the channel in small globules, giving to the stream an assumptive property, not altogether unlike an economic soda water. These lids may be made of tinned copper, and where the vats are large, may be suspended over them from the roof or ceiling, so as to be drawn up and down.

Wherever local circumstances effectually prevent the increase of temperature after pitching at between 40° and 50°, the cover will not be absolutely necessary, because air cannot be engaged in injurious excess. The principal and perhaps only definite use of it is simply to drop it on when it is found necessary to curb or stop the fermentation, which the exclusion of the air would sufficiently do. In this case, the rim should dip five or six inches into the water, the more effectually to cut off the supply of oxygen, and to increase the pressure of the gases on the must; and means can easily be adopted to maintain the pressure, if found advisable, during the attraction and precipitation of the yeast, and even under racking.

As alcohol does not combine with oxygen from the air at common temperatures, that is, at temperatures which in fermentation are accounted low, or beneath the medium, and as experience shews that the exclusion of the air greatly checks the fermentation, these circumstances constitute the reason why, when the heat is much reduced, the cover will not be needed; because the alcohol will prevent all the saccharum from being decomposed, the ferment can be sent downwards by precipitation, and the ale can at once be racked off bright, if required. When the cover is left on, the heat cannot rise into the atmosphere; and if it be not transferred through the sides, and carried off by the attemperating water as fast as it is generated, it must accumulate in the must, and keep it a few degrees higher than the abstracting water; yet the use or absence of the cover will be optional, according to the state of the external atmosphere.

Timid people may object to fermentation under ground, through apprehending some accumulation of carbonic acid gas in the vault, which may have a ten-

dency to endanger life; but there is not greater risk here than in any other confined room, as the gas, by subsiding upon the running waters, is carried off in the draught and current. In breweries of the usual construction, there are on record several awful instances of its deadly effects upon certain brewers' labourers and others, who have imprudently ventured into vats without ascertaining whether they were quite clear of that noxious gas prior to their descent. The usual and most certain proof of its presence is the introduction of a light, as carbonic acid gas will not support combustion; and as a test of this, if a lighted candle be lowered into a vat which has lately contained malt liquor, the light will instantly be extinguished by the power of the gas, in the absence of atmospheric oxygen, below which the former sinks by its own gravity.

To countervail the dangers and consequences hence arising, the assignment of the province of examining these vaults to a careful workman of sufficient ability must be evident, he having intelligence, attention, and thought, superior to the persons usually selected in breweries because of the bone and muscle which they display beyond men of ordinary strength. This person will have the especial duty of clearing the water and gas from the tun-room; and to facilitate his duties herein, the author has invented

The Pneumatic Life-Protector.

As the subterraneous fermenting-room, when not situated on a declivity, or where a natural sloping gallery or drainage cannot be obtained, will be liable to the objection of insecurity to the lives of the men there engaged, notwithstanding the provision of pumps and other remedies and preventives, inasmuch as they may not always be duly worked, therefore to render the

place both healthy and safe, by superseding the possibility of any such evil effects, unless from the men's own gross neglect, let a lamp be fixed near the doorway of the staircase or geometrical shaft leading to such subterraneous room, and let a small metallic tube or air-pipe be attached to the bottom of it, long enough to reach to about six or ten inches from the floor, and by this contrivance all the air consumed by the lamp will be supplied from below; then it must be clear that the air suitable for combustion, and consequently the light so circumstanced and affected, will cease to burn as soon as the gas touches the orifice; for as carbonic acid gas is heavier than atmospheric air in the proportion of 1527 to 1000, as soon as it is thrown off by the worts, it will accumulate upon the floor and increase in depth until it reaches the lower end of the air-pipe, on which the dense gas will act as a valve, and prevent the admission of air suitable for combustion.

Having taken this precaution, all persons entitled to enter the tun-room will possess a foreknowledge of the state of the air; therefore if any one descends into the cave when the lamp refuses to burn, he does so at his own peril, and the loss of such a person to the community will be something like that of a madman. A lamp on the same principle as the former, having a tube that supplies it with air from the tun-room, should also be fixed in the engine-house, or within the stoker's room, or indeed in any convenient place which is often used, or is constantly passed by the stoker, or by the manager of this department, who will have a duty to perform similar to that of a tide-waiter, or a pilot stationed at the crossing of a railway with a common road, which will be to refuse admittance at improper times; and a beacon of the same kind will be found in the Caloriphagon, for that being supplied with air upon the same

principle, in case the pumps should be neglected at the time when the men are engaged below, notice of such neglect will first be indicated by a lowering and discoloration of its light, until ultimately, when the gas has increased in depth till it has reached the bottom of the pipe, the extinction of all its light will envelope the workmen in darkness, and they will be obliged to leave off working to walk out of the reach of danger. Thus all hazard arising in subterraneous vaults, *constructed without a gravitating drainage*, is successfully averted, and the men can perform their few occasional duties within it in quite as much security as in the old establishments, and in greater safety, because of the warning; and when a descent below the bed of the room can be had, which will always be a point in contemplating a new erection, no such danger can arise or be anticipated, and consequently none of these precautions can be at all necessary; and besides all this, the alcohol, unaffected by the vicissitudes to which houses of the ordinary kind are subject, is preserved and fixed in all the vigour which appertains to its character and constitution.

CHAPTER XV.

GENTLE FERMENTATION.

SKIMMING PROCESS—THE TREPIDATOR—RECLUSE FERMENTING—REQUISITES —TUN-ROOM ATTEMPERATORS—NORTHERN BREWERS—DOUBLE SQUARES —BENTLEIAN SYSTEM—CRITIQUE UPON IT—CORRECTIVES—FLATTENING —URE'S PRINCIPLE—HARVIE'S CLOSE GAS PATENT.

GENTLE fermentation is a calm and gradual process, producing natural consequences in perfection, and then subsiding into quiescence, just as the case is with all nature's most exquisite and marvellous productions: thus daylight and darkness come on by degrees; tides as gradually flow and ebb; flowers and all vegetable families bud, gain strength, beauty, and maturity, and silently wane into oblivion; animals wax and droop by similar steady process; and the seasons follow one another almost imperceptibly. Fermentation by natural means, however new as a brewing measure, though called an oxidation according to the phraseology of the modern school, is progressive, not by making an oxide of the alcohol, because, as has been shewn in the preceding chapter, that cannot be done under the conditions, but is an oxidation of part of the raw worts; and this is an invariable preliminary, inasmuch as it is self-agent, or the wort could not undergo the necessary decomposition to which it approaches step by step with certainty and precision. The *glutin* of Saussure, or *kleber* of Einhof, which is the principal nitrogenous

matter of the native gluten, being actuated by an innate and sleepless propensity, is among the first constituents to decompose by absorbing a surcharge of oxygen from the atmosphere, or from the sugar, as the constituency may allow, and to commence decaying. This species of fermentation produces a very protractive decomposition of the sugar, mild and gentle in character; and the accompanying gluten, which only is decaying, takes no part in the vinous fermentation of the sweet principle, nor can the action of the decomposing sugar alter the peculiar species of change which the gluten and yeast are now undergoing; thus it will be understood that the nitrogenous matter is appropriating to itself the oxygen which assists in its decay, while the saccharum is dependent on the desertion and progress of decay in the glutinous compound. By this novel commotion and contagion, which it spreads everywhere in its existing course, the *kleber* is made to assume the diastatic property, and to act as though in concert with it throughout the vinous fermentation, forming alcohol, yeast, and carbonic acid, as before explained, the first being intimately united with the water, the second precipitated to the bottom of the vessel, and the last flowing away with the running stream.

The material on which the brewer has to depend for the production of a fermentation purely vinous in its nature, is his saccharum, no other being capable of the conversion; and this remarkable fact is a good argument in favour of either preserving the diastase from destruction by fire after it leaves the mash-tun, or of making the most of it there; for we have before shewn that it does something more than merely break the amylin and set the amidin free; and notwithstanding that a species of saccharising fermentation precedes the vinous in the gyle as well as in the mash-tun, the

alcoholic production from sugar so formed, and apparently so prematurely decomposed, is not so copious, or of so fine a quality, as that made from ripe, well-matured, and perfect saccharum.

Although the remarks now further offered on this head might be generally extended to the extracts of grapes and other fruits that contain the essential constituent, and are, upon decomposition, subject to the same or similar laws, and will bring forth kindred issues, it will be more convenient and consistent with the object sought, to confine the observations that arise chiefly to the produce of malt and hops, as used in the brewery, although such theoretical and practical remarks would be applicable, with very trifling modifications, to the productions of the vineyard, the garden, and the orchard; but it is presumed that a mental view of this matter will easily transfer the idea to the foreign object.

The materials considered requisite for establishing a correctly vinous fermentation are four: sugar, water, modified heat, and a little yeast. The first of these, accompanied by gluten, and too frequently by large quantities of unconverted starch and starch gum, is plenteously and variably supplied from the mash; the second by the necessary means of dilution therein; the third, under certain limitations, puts all the particles in motion when induced by the fourth, which is the ferment itself, posited within its appropriate sphere. Thus constituted, the *new* mode of fermentation very closely resembles the Bavarian process, so clearly and scientifically described by Professor Liebig, with the exception that in lieu of exigencies and contingencies, we establish definite and fixed principles. The British public ought to feel bound in gratitude to this eminent chemist for the information his labours have elicited; and in justice

to that public, as well as in support of the present author's own peculiar views, he gives that philosopher's investigations and opinions as an act of triple duty, as often as the extreme novelty, profundity, or significance of the subject requires concurrence of idea to give due weight to its importance. Bouchardat's experiments will be found to confirm his testimony, where he lays down the doctrine already referred to, that when common yeast is put to wort of 40° to 45° temperature, a tranquil fermentation takes place, depositing at the bottom of the vessel a substance which will excite new fermentation, and that when repeated several times successively, the ordinary fermentation graduates into the process which alone forms precipitated yeast; the yeast so deposited having lost the property of exciting fermentation in the common way, but producing that other process even at 50° F.

In order to facilitate a comparatively vigorous fermentation in saccharine liquors at extremely low temperatures, such as from a multiplicity of obvious reasons have been here recounted and advised, and for which other reasons have to follow, a certain degree of motion amongst the constituent particles and atomic elements is necessary. In ordinary fermentations, a sufficient agitation is generally produced by the generation of an additional amount of caloric, and the universal commotion that it causes by the ascension of the heated particles, aided by the escape of gases; but in such fermentations as evolve little heat, it is requisite that the nitrogenised matter should be kept by artificial means, such as occasional agitation, in perpetual contact with the sweet parts of the compound; for otherwise its glutinous portion would prematurely coagulate and fall inert to the bottom of the tun, leaving an inefficiency of

its soluble matter in the must to complete the decomposition of the saccharum.

In lieu, then, of the usual method of rousing, the author proposes to use his patent light implement called

The Trepidator.

This internally agitating machine, which in mechanical form is something like Captain Carpenter's submarine rotatory propeller, may be thus described:—an upright shaft is provided with a handle or winch at its top end, a projecting blade at its other end, and another blade or two on the same shaft, made to slide so as to suit the depth of the gyle, each blade being set at a different angle from the others, so that when in action, the various directions of the revolving blades impart to the liquor an active commotion. This trepidator having been placed within the fermenting wort, and made to rest upon the bottom of the square, a revolute motion is given to the shaft and its blades by turning the winch with one hand, while the other is occupied in holding the frame of the machine steady. In this way it is light and portable, can be used in every part of the square, and in every portion of that part, as may be found desirable, the bottom blade having an universal joint, adapting itself to any angle formed by the inclination of the shaft. The ferment will thus be thoroughly aroused from its slumber, and those parts of it which have not lost their vitality, will be induced to resume their decomposing influence on the remaining sweet, whose more rapid transformation it is desirable to hasten. Such an implement as this, the price of which will not exceed a few shillings, it will be proper to have at hand; but the patentee would not recommend that it be used, except under the betokening of such peculiar circumstances

and symptoms as in a measure enforce its application as necessary.

Worts fermented at the proposed low temperature retain their own native air, that is, their carbonic acid gas, longer and in greater quantities, the process being of a nature so calm, from the absence of much heat and motion, that it doės not expel the globules and force them away, except when in excess; having no opportunity for escape until it is poured into the goblet or cup, when it will produce a brilliant and sparkling appearance, equalled only by its delicious, light, aromatic, and spirituous properties.

It is well established in the minds of those who derive correct ideas of effects from the investigation of causes, that the shorter the column of the fermenting fluids, the less is the pressure on the lower constituent atoms of the mass, and with the greater ease do its elements move, act and react on each other, and change their constitution by partaking of the new arrangements and properties enforced by their decomposition. Upon this principle we may account for the motive of the Bavarians in adopting the wide fermenting vessel, besides the object of facilitating the absorption of oxygen from the atmosphere by the gluten. The shallowness of the fermenting tuns also prevents the accumulation of superfluous caloric, and brings the main body of the wort into contact with such of the precipitated yeast as may have coagulated and fallen, through the cooling influence of the attemperating media.

The system of little or no boiling has for one of its chief objects facility of fermentation at temperatures extremely low; and no good opportunity should be lost, nor should any scheme be omitted, in carrying out the principle to its greatest and most advantageous extent; but it should be nevertheless understood, that the same

quantity of carbonic acid gas, and also of caloric, is generated in low fermentations as in worts attenuated at any higher degrees of temperature, provided that the former and ultimate densities are equal, or, indeed, in all other instances of similarity, in the commencement and issue. In the former process the heat, &c., is absorbed and removed by artificial means; but in the latter it appears more evident from being allowed to accumulate, and to accelerate the process. Hence the difference of time occupied by each; but it is not impossible to cause the cool fermentations to be as expeditious as the others, were the end desirable, and the means of its attainment as demonstrable as futurity may disclose.

In summer brewings, the trade have commonly found it advisable to attenuate, so as to insure just sufficient alcohol to check a further decline of the remaining saccharum; but this design is commonly frustrated by the danger of the whole gyle becoming yeast-bitten; and it often happens that by avoiding this one calamity, they incur another, and perhaps more than one, such as fretfulness, cloudiness, sweet clamminess, and ultimate acidity; so that in a warm atmosphere, or in a situation affected by a sudden transition or variation of caloric, or any heat above 55°, the attenuation of the saccharum never can be uniformly perfect, nor can the alcohol be secure from the attacks of the oxygen; for the ordinary heat of pitching the worts is seldom below 56°, and this of itself is sufficient to decompose the alcohol, which decomposition increases with the rising heat of the fermenting gyle, which in some cases, as has been shewn, exceeds 80°; whereas by the plan now proposed, the fermentation will be closed and perfected, and the ales can be racked off at a temperature many degrees lower than that at which they have usually been pitched, and can never exceed that at which they leave

the refrigerator, or from 45° to 52°. There is little danger of yeasty ales, or of extreme injury from either high or low heats, in the breweries of experienced and skilful managers, whose wisdom has adopted the artificial cooling means of attemperators, and other similar necessary implements.

As the fermentation has proceeded with little variation and no interruption, and as the alcohol is unmolested by the oxygen, even at this highest heat of 52° F., and as the very limited supply of heat throughout the process causes all matter which favours acetification to become insoluble, and consequently harmless, and of easy ejectment or precipitation, so are the liquors drawn off uncontaminated, either by yeast or by acidity. Such fermentations are also out of the influence of light, electric action, and the circulation of varying currents of air. The aromatic oil generated during the fermentation is also retained, thus increasing the pungency and spirituosity without additional materials. The alcohol formerly lost being converted into acid or ether, the necessity for an enlarged quantity to be produced to shield the acrid taste, and to ward off acidity as long as possible, is all saved here, so that fewer materials also are wanted to make beer of the same strength. This stands fully exemplified already; in addition to which, the author can verify that this kind of fermentation has often been practised upon worts from 22 to 36lbs. *per* barrel, which had been extracted and hopped according to the new theory as here established; that the heat of the fermenting gyle never exceeded 45°; that the attenuation was in every instance much lower than on the ordinary plan of fermentation, the time of the process having varied with the density of the wort, and occupied from two to four weeks in each case; and that the ale so produced is brilliant and highly spirituous,

and very rich, though not in the manner called luscious. Indeed, experience proves that ales brewed upon these principles, are the most manageable during any part of the process, and are capable of the nicest modification either in flavour or in spirituosity.

> "Nor wanting is the brown October, drawn
> Mature and perfect from the dark retreat
> Of thirty years; and now his honest fount
> Flames in the light refulgent, not afraid
> E'en with the vineyard's best produce to vie."

Thus, then, is perfected in greater security, a purely vinous fermentation; and the correctness of the foregoing will be further substantiated if we consider that the lower we keep the heats of the fermenting tuns during the whole process, provided that the ultimate transformation of the sugar is as perfect as we wish, and its transparency speedily secured, the finer and sounder will be the ales of such worts, and the longer they will retain their fresh and spirituous qualities. On the contrary, the higher the heat, the more rapid the fermentation, and the more are the most volatile parts of the beverage dissipated with the carbonic acid, whereby its flavour and strength are not only deteriorated, but may be totally lost; for the capacity of the air above and around the tun, is increased and rendered fitter for the attraction and absorption of the spirituous vapour and fine aroma, by the radiating heat of the tun itself. Even after such ales are bright, and they will not at all times readily become so, they will be far inferior in strength and flavour, and in every keeping quality, to those fermented in cooler situations, and at a lower heat. The higher the heat of the tun, the more numerous are the particles of yeast, &c., held in solution, and the more firmly are they incorporated with the liquor, and hence its turbidity and one cause of its early sourness.

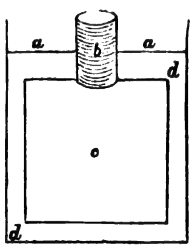
Should the pump, or other machine for changing the air of the vault, be wrought longer than experience finds necessary, and such can only be the case when all the carbonic acid gas has been removed, such over-work of time and waste of labour bring too much external air to occupy the subterraneous precincts, and thereby for the time to raise or depress the temperature of the room, and to cause a consequent fluctuation in the fermenting temperature and process by disturbing their equilibrious constancy:—it is only necessary to say, that an experienced person will avoid repetitions of that practice as much as possible, by preventing any accumulation of noxious gas upon the floor, as directed in the preceding chapter, page 441.

TUN-ROOM ATTEMPERATORS.—In reviewing the various improvements brought into the brewery prior to 1841, the introduction of attemperators into the fermenting vessels must be considered the greatest and most valuable. The first was introduced by Dr. Shannon in 1808, and is now called the "Portable Book Attemperator;" the idea, however, gave rise to a variety of shapes and contrivances, till after the lapse of a few years, fortunately for the public, competition in the brewing world increased, and their utility became better understood, but not till lately did they become generally known. Those now in most common use are coils of copper tubing coated with tin, fixed upon brackets or upright iron standards, 12 or 20 inches from the sides of the interior of the rounds or squares in which they are inserted; but they are all inadequate to the purposes for which they are intended, though capable of being enlarged in their dimensions, applications, and use; this is owing to their limited length, their cooling medium, which is their surface, not being adapted to carry out the principle of extracting the caloric in sufficient

quantities, and of overcoming the influence of the external atmosphere in a decisive and effectual manner. Of these attemperators, some notice has been taken in Chapter XI. of this work, p. 346, &c.; and there are some others which admit of the two following improvements. Instead of merely conveying the cold liquor into the body of the fermenting fluid, and thence directly away to *waste*, they should be made stronger, to enable them to withstand a greater pressure from the column of water that may press upon them, if carried up to a back placed above. The cold liquor should be let in near the bottom of the tun, and circulate its course upwards through the yeasty head, a few feet above which the tube ought to take a horizontal zigzag form, and ultimately continue a direct course upwards, into a second liquor-back; by which extension of the cooling means the heated carbonic acid gas and atmospheric air, &c. &c., convened or hovering above, would be cooled, condensed, and rendered similar in effect to a natural favourable season, less attractive and absorbent of the spirituous and aromatic vapours brought over by the ascending caloric, which, under circumstances, escape from the gyle in warm weather in no small quantities, to the impoverishment of the article.

The principle can be carried out to still greater advantage, and more economically, on the erection of a new plant, as follows:—In districts where large slabs of good durable stone, free from iron, come under the price of slate, they may be employed in the construction of cubical vessels of a convenient size, having all their dimensions equal and their strength uniform; because then, as observed in Chap. XIV., the *minimum* of surface contains the *maximum* of capacity. In the middle of the upper face of each, let a man-hole be cut; on the margin of each, place a tinned copper tube, strongly

flanged, of about two feet in diameter, and of the same length, and fasten it down by bolts and nuts of the same metal. The tun will now resemble a square black bottle, with a round white neck. Now envelope this cube within another parallelopipedon of the same material, but 8 or 10 inches wider than its outside each way, and about 30 inches deeper, keeping their bottoms and sides 4 or 5 inches apart by means of slate or other strips, so arranged as to give a proper circulating direction to the water intended to flow under, and completely round, all the six sides of the inner vessel, when containing wort. About 20 inches from the top of the larger square, insert within it a horizontal partition, which shall preserve a cavity of 4 or 5 inches deep above the upper surface of the inner square, through which partition the copper cylinder will now protrude, and its over-surface will be on a level with that of the outer square, the uppermost part of which will now constitute a *barm-safe*, 18 or 20 inches deep, and having the full area of the square, as in the annexed diagram, where *aa* represents the barm-safe, *b* the man-hole, *c* the wort-square, and *dd* the water-space.



In the bottom of the barm-safe, and leading into the inner square, let a tube or two be placed, with valves opening outwards. When in use, this double fermenting vessel will then enable the operator completely to envelope his worts in water, and to keep them in subjection. The projecting man-hole may now have a loose cap or cover, deep enough to drop into the barm on the safe, and it will be found of good service after the fermentation is over.

This square is like those that are used to such notable advantage by the great Yorkshire brewer, Mr. Bentley, whose establishment is near Rotherham, and by a few others in his neighbourhood, who have endeavoured to follow in his extraordinary and successful path; except that it is an additional improvement by introducing the cover and the horizontal water-course under the barm-safe and on the head of the must. No little art and practice are essential to working attemperators of the simplest kind, and yet greater skill is wanted to manage the double square than any other species. The brewers in the north may be supposed to have understood their calling better than others, from having thus availed themselves of the advantages derivable from the use of low fermenting heats, though many of them have hitherto been obliged to work their gyles at many degrees higher than can be recommended; for these squares are of little advantage if any, where a deficiency of spring-water is experienced. In this case, the Bentleyites would find the horizontal portable attemperator preferable, as it economises water, and is more immediate in its effects; instead of seeing which, the high heats which they cannot possibly restrain within due compass, dissipate the most valuable parts of the liquor by an excited evaporation, those parts being, as elsewhere shewn, the most volatile; therefore, the advocates of such a plan, under such circumstances, instead of creating the lightest and purest alcohol, implant that radical cause of acidity, that foe to spirituosity, atmospheric oxygen. The like result is especially evident to observers who use settling backs, and when the atmosphere is in its most recipient state, or in warm weather, though the article may have subsided to its cool and full quiescence.

But these schemes, taken as a whole, are invaluable under proper management, if only in their minor appli-

cation of rectifying any misfortune that arises from neglect, impatience, or accident, in the pitching heat, or extreme or sudden atmospheric changes; as water may be employed either hot or cold, as occasion requires. Although the metallic tubes and mineral passages are nearly allied in principle, the use of them by their respective managers is dissimilar; and moreover, *both* parties vary in their management, according to the circumstances of talent, custom, necessity, and so on. Still a brief description of that which is conceived to be the most consistent and successful course of practice under these two systems may be necessary.

First, as regards the tubular attemperator: the flavour of malt liquors depends as much upon the degree of heat experienced during the fermentation, as upon any other distinct cause, the quality of malt and hops not excepted; for the more boisterous and violent the heat becomes, the ranker and more arid is the flavour, and *vice versâ*, mildness produces mildness. Those who depend upon nature in her mood of frolicsome or stubborn instability, therefore, and work without any attemperator, can seldom make a full flavour, with a sufficient degree of spirit in their ales, during the warmer months of the year; but with a good apparatus, instead of submitting to the external influence of a hot atmosphere, the redundant heat accumulated by the vigour of the fermentation can be extracted, a gradual decomposition of the worts, at a comparatively moderate and secure temperature, can be effected, and an article tolerably uniform in flavour can be ensured at all seasons. Immediately after the vinous action has commenced, cold liquor may be passed in a gentle and regular stream through the attemperator, just fast enough to allow the generating heat constantly to have the ascendency, and to increase at the rate of one degree for every three or

four pounds of attenuation in ales of moderate strength; and for the stronger brewings it may be necessary, and probably more convenient, that the heat should increase yet a little faster; but the cleansing point will, of course, depend upon destination as well as strength: if for immediate consumption, it will not be far wrong to fix it at from 2 lbs. to 4 lbs. below one-half of the original density. When the proper period has arrived, and where the place affords plenty of square-room and water, the skimming process can be safely commenced, and with advantage, or the fermentation can be finished in the square by skimming off the yeast tolerably clean, occasionally repeating the operation during the following 18 or 24 hours, and the cold liquor must also be turned off until 2 or 3 lbs. more are attenuated, and then the processes of skimming and fermentation ought to cease. Recourse must again be had to the attemperator, and the heat of the gyle must be reduced as much as possible, so that the suspended yeast may now fall to the bottom, and in a day or two more the gyle will be fit to cleanse, or rather to rack, the skimmer and cold water having cleansed it already; therefore, it may at once be put into the casks to be sent out.

This is the principal object of cooling as low and as speedily as possible, though in winter time care should be taken not to cool below 40° after the fermentation has closed; for although the temperature of the store may affect it, yet the excitable yeast is not present in quantities that can cause immediate mischief, or render the necessity of leaving the bungs or shives out as long as is usually done, to prevent fretfulness, and to secure early and permanent transparency.

Second, as regards the double square more generally.—The working of this utensil need not vary much from the preceding course, yet the system pursued by the

Yorkshire brewers, who originated it, and unhesitatingly follow it at the present day, is essentially different, their worts seldom being pitched higher than 60°; and it is customary with some of them to pitch them in a common square, placed above the double one, and there to keep them until the fermentation has commenced, before they lower them into the latter; and from this top square they fill up the lower, as occasion seems to require, and always near the close. The ales in general consumption with them average 26 lbs. *per* barrel at pitching, and about 8 lbs. when bright, according to Long, or Dring and Fage, the heat of the fermenting mass seldom being allowed to exceed 62°. When the attenuation is perfect, they use a vast quantity of cold well water, and aim, if possible, to reduce the heat down to between 54° and 56°, and there to keep it until the article is racked for sending off. Where the squares are in sufficient number, a small store-room suffices.

These are the principal features of their practice, which those who never adopted similar artificial means would deem tardy; but though a little slow, the process is certainly sure, and is not so slow as the undisturbed Scottish mode in general, the Yorkshire fermentations seldom occupying above a week. The large quantity of cold water necessary to extract the caloric from the gyle, is perhaps an obstacle in many situations, and especially where the bulk is large; for it is not always an easy task to bring the temperature even to within 5° of the heat of the water, except in cold seasons. The men who have the management of this department find it necessary, at a certain stage of the process, to stimulate the fermentation from time to time by lifting the valve in the safe, and letting down the yeast which issued from the man-hole, and has accumulated on the

safe; and at the same time they draw up to the top, by means of long light portable pumps, the yeast that has subsided, and with it a quantity of the must; it then falls upon the barm-safe, and finds its way down through the valve openings into the square again, and thus the contents of the square become aerated, their once quiescent particles are deranged, and the decomposition is invigorated. This apparently desperate state of excitement is kept up as intervals require its renewal, nearly till the close of the attenuation, when the valves are shut down, and the man-hole is kept sufficiently full for the must to be nearly on a level with the barm bottom. The safe receives the barm unmolested, and when it subsides and solidifies, and its accompanying liquor is fine, the valve is lifted, and the liquid runs into the square again, leaving the barm behind.

The remarks of a Scotch writer on the influence of electricity apply here, as they undoubtedly contain truth, and his advice to isolate all vessels containing vinous liquors is good; it is therefore wise to roll the casks on strips of wood, instead of the floors of store-rooms; but if metals are such dangerous conductors or generators of galvanism, as he avers on the authority of another noted writer, the metallic attemperators are advantageously superseded by the cavity formed between the two cubes of the double-square vat, and their tubes are out of the way of the cleansing broom and mop, unless precautions are taken to avoid improper combinations of materials in their construction.

The Bentleian system is extolled by all practical men who have had the good fortune to become acquainted with it; yet it is not wholly unattended by the troubles common to other brewers during the warmer months of the year, though the extent of difficulty is not so great as usual. It is undoubtedly the most economical and

least irksome process yet practically adopted upon a large scale; and (respect being paid to original density and *cæteris paribus*) the beverage which it produces contains the greatest quantity of alcohol and carbonic acid gas, and keeps fresh and brisk, and in general good condition, longer than any other brewed in this country.

Admirable as these schemes are, in comparison with the old and worn-out chance-work of fermentation, yet we must admit that, after all, they are but poor and costly substitutes for the unerring laws of placid nature under such favourable circumstances as constancy in climate and temperature, or as a *subterranean fermenting vault*, where the water will work into a drink of the finest and most exhilarating quality, without either risk, stimulants, restrictions, or trouble; dispensing with no small share of that tormenting, painful, and wasting anxiety, which falls to the lot of every practical brewer who, to the best of his too often inadequate means, knows and does his duty to himself, his employers, and the public.

A custom prevails with many who use the skimmer, as with others who cleanse into pontoes, of employing wheat-flour mixed with salt, to be wrought into the gyle after the first or second skimming; the professed object with some being to stimulate the fermentation, and create carbonic acid gas to float the barm upwardly, while others consider it to have just the opposite effect of retarding the further progress of the fermentation; and recently, a few have abandoned the flour to substitute bean-meal, each in his own view supposing the latter to have a better effect; though of these two materials, from their widely different constituents, as published at p. 28, and subsequently explained, they appear to know exceedingly little. Doubtlessly, as a reviver of decomposition, wheat has the advantage, because it

contains a large quantity of the necessary constituent gluten, which acts as a ferment on the unattenuated mucilage, &c. of the must; but beans, on the contrary, as has been examined into at p. 55, appear to be destitute of this azotised ingredient; therefore, whatever be the value of the assistance given by this meal when decomposing, it must chiefly depend upon its meagre supply of albumen; and peas, composed of C. 35·74, H. 5·4, N. & C. 39·37, ashes 3·49, water 16, *per cent.*, are so much like beans in their composition, that their disqualification appears as pronounced at p. 54. Salt is a retarder of the process, therefore it cannot answer the designs of both parties alike; indeed, were the gentlemen who use either to examine the constitution of the yeast that succeeds this corrective addition and rousing of theirs, they would perhaps discover for the first time, that, besides the glutinous composition of the extract, it consists of nearly the whole of the flour or meal so united. The gases disengaged from the must by the mechanical agitation, seize immediately upon the particles of the floating flour, and adhere to them, buoying them up so rapidly at the surface, that no time is afforded for their decay, or even for their saturation, neither at the same time does much yeast come up with them. In short, the utility of either, with whatever agitation it may be used, is altogether questionable, so much so, that the author's experience convinces him that he is better without the trouble, risk, and expense of them. According to Booth, *sal prunella*, mixed with wheat flour, is used at cleansing to promote the *discharge* of yeast, or previously to prevent languor.

Many London brewers of the first respectability annually waste loads of one or other of these alleged correctives, evidently to their own detriment, and they are well known to be wedded to the practice, and

are accordingly enamoured of it; therefore he may yet expect from some of the fraternity more byeblows than compliments of credit for continuing to expose their thoughtlessness, and has only to echo his former reply, gauntlet still in hand,—"Lay on, Macduff."

We will conclude this chapter with a description of the new patent which is applicable to it in some of its bearings. The patent was issued in November, 1842, to Arthur Harvie, Esq., of Wilmington Square, in the county of Middlesex, for "a method of conducting vinous fermentation in close vessels, in such a manner that the gas evolved may be conducted under and into liquids undergoing fermentation; and the gas may be further usefully employed by being conducted under and into liquids requiring to be saturated with carbonic acid." The apparatus is as set forth in the subjoined abstract of the Specification, and is called, from the name of the inventor,

HARVIE'S PATENT.—In the drawings annexed to the Specification, 1. Four tuns or vessels appear as if placed in a direct row, of which Nos. 1, 2, 3, are fermenting tuns or vats, and No. 4 contains water, solution of potash, solution of subacetate of lead, or any other fluid or combination of fluid matter which the operator may wish to charge with carbonic acid, which may be a tub, a vat, a hogshead, or any other vessel. The inventor prefers having three vessels of the first description, which, we presume, work triangularly, but any other number may be used where found convenient.

2. The heads of the vessels have, of course, holes in them, to admit the fluids to be fermented, and are made large enough to permit their cleansing to be carried on within them, and so contrived that they can be shut air-tight. Within these orifices air-tight pipes for the conveyance of the carbonic acid gas from one vessel to

another (constructed thus to receive it freely, as it is ejected,) are inserted, so fixed, that they may be readily taken apart and cleansed whenever necessary, and arranged thus: each commences at the top of one of the three or other number, and descends thence into the body of the fluid fermenting in another, as from No. 1 into No. 2, from No. 2 into No. 3, and from No. 3 into No. 1 again, or according to the number in the circuit, which is completed at the vat where the series commenced, and the gaseous contents evolved in the whole range and here collected, empty themselves in like manner into No. 4, or isolated vessel, which may be open or close, as the destination of the gas may require. These pipes may be made of tinned copper, or any other material fit for the purpose.

3. This last pipe, which is for the express purpose of clearing away the carbonic acid gas from the fermenting must into the vessel placed for its reception, must be of such length, and the receiving vessel must be so stationed, that the exit end may reach lower than those of the former pipes, by which means the pressure of the carbonic acid gas in that direction will be greatly increased, and the effect will be the accumulation, in one focus, of a greater volume than is obtained by any ordinary process.

4. When the fermentation is over, which will last the usual time, the tuns, &c. may be emptied at their bottoms, or by any convenient means as heretofore, but they must be filled to within 18 inches of their brims; and to prevent any passage of the fluid from vessel to vessel when over-filled, some care will be requisite; so that to work this invention to the greatest advantage, the fermentation must be conducted at the lowest temperature possible, as it is desirable to evolve the carbonic acid gas as slowly as can be done.

The advantages arising from this management of the vinous fermentation by means of close vessels, and causing the gas to be again conveyed into the fluids whence it was evolved, as above described, consist in producing a fuller and more complete decomposition of the matter subjected to the fermentation, thereby obtaining a greater quantity of spirit, through the gas, especially towards the close, being returned and compelled to pass and repass into and from the parts of the fluids under process before it finally escapes, so that it becomes a very beneficial agent in fully fermenting the fluids, in addition to its being collected for after-employment.

The patentee claims the merit of having thus invented a new and improved mode of conducting the vinous fermentation in close vessels, and will not confine himself to any precise details, but to the peculiar character of his invention, of which the above is an outline.

CHAPTER XVI.

RAPID FERMENTATION.

CONTRARY EFFECTS—ALDEHYDE ANALYTICALLY CONSIDERED—ACETIC ACID AND ALEGAR—OPINIONS AND TESTS—MORE ILL EFFECTS OF HEAT—ALCOHOL ANNIHILATED—ATOMS OF SPIRITUOSITY—COMPARISON OF SYSTEMS—HAM'S VINEGAR—LONDON SAPIENCE—ATTENUATION PERFECTED—BRITISH MALT CORDIALS AND WINES.

Having now shewn the effects of moderate temperature in the vat or gyle-tun, we may thence proceed to examine that species of fermentation which is commonly termed acetous, with the causes of its production. Vatted ales, as well as new wines, that have been fine in the winter, often undergo a secondary and more expeditious fermentation on the approach of summer, or rather an increased action, because the fermentation, if properly conducted, has, in fact, never entirely ceased; and hence the cloudiness of beer at certain points of its progress that have occurred, under the most favourable circumstances, even as now conducted; hence, too, the incorporation of its lees throughout the whole mass, and the freedom with which it "ages," or becomes hard and afterwards sour, which changes are the sure effects of heat, aided by the restlessness of the unsubdued ferment in its now exhausted and expiring extremity; but in ales that are removed from their depuration during the cold season, such atmospheric changes are not so

perceptible, nor is the acidity so intense; which shews that heat is productive of acidity.

Dr. Thomson states, that when beer is deprived of its glutinous matter *in toto*, whether by spontaneous deposition or by clarification, it will not submit to the acetous fermentation, unless some *mucilaginous* matter be mixed with it; and here the author must explicitly observe, that the case differs in ale in which the mucilage has been converted into saccharum. In the Annales de Chimie, XXXVI. 245, Chaptal shews that he exposed old wine, freed of its mucilage, in uncorked bottles, to the greatest heat of Montpelier, during 40 days, and that it did not become sour by the exposure, though on adding vine leaves to it, containing mucilage, it then became sour in a few days; and it shall be shewn in the sequel, that British beer may be found which will stand at least an approximate test. This, by the way, is old beer, brewed temperately for long storage; hence, as mucilage is such a powerful and universal agent in producing acidity, when acted upon by a little heat, the super-eminent utility of the mashing attemperator to nurse that constituent into sugar, as directed in Chapter V., is unquestionable.

Heat is produced in various ways, as by the union of alcohol with water, or by chemical action in the conversion of sugar into alcohol, which is a fermentative because a generative process. Some have supposed that the increased heat within the tuns was caused by attrition or friction among the contents; but Pictet has demonstrated that solids are the only substances which can produce heat by friction, and that no elevation of temperature whatever takes place from the mere agitation of fluids or their particles one with another. The primary supporter of heat and combustion of oxygen, is feelingly described by Booth in the Society's Trea-

tise, p. 28, where he says, "The formation of vinegar, like other fermentations, proceeds more rapidly where it has a *nidus* or incipient acidity from which to begin. In the aërial theory, that *nidus* is oxygen, and to destroy or counteract this oxygen in the outset, is to *strangle the demon* in the moment of its birth;" which moment may be either within the period of mashing or at any subsequent stage; but he seems particularly to charge the act of "*blinking*" in the newly drawn worts with being the mother of the demon, and "*improper heats in the mash-tun*" as its sire. That the imbibition of too much of this element is fatally productive of acidity, enough has been said herein, whether its vehicle be unconverted mucilage, or alcohol accompanied by mucilage, or an incurable aërial blink, all of which contain hydrogen in superabundance. A certain degree of heat is requisite to oxidise alcohol; but to effect this, a sufficiency of oxygen must be supplied from the air through the nitrogenous agency of some substance in decomposition, its decay causing not only an influx of oxygen in excess, but when a certain amount of caloric is present, the subtraction of a portion of hydrogen from the alcohol; and if its atomic weight is thereby diminished one 23d part, a substitution of oxygen annihilates its water, and again commonly adds to its elementary constituency one-sixth *per* atom of its former alcoholic weight; for the atomic weight of alcohol, where oxygen is unity, is 5·75; that of aldehyde, its first transformation, only 5·5; but that of acetic acid 6·375, as will be seen on reference to Chapter XIV. p. 421-2, above.

But the atomic weight of a particle in composition, is distinguished from its absolute or specific gravity, inasmuch as atoms differ in magnitude: œnanthic ether, for instance, which gives odour to wine, has a specific

gravity of 862, with an atomic weight of 18·75, whereas an atom of alcohol of a specific gravity varying from 813 to 863, is not equal to one-third of the former, as before seen. In the transmutations before us, however, the disparity is not eccentric, as aldehyde has a specific gravity of 790, which is one 23d less than 826, or a mediate gravity of alcohol; but the specific gravity of acetic acid is 1060, which shews that the atomic increase is not equivalent to that of its specific gravity, entitling it only to 915·7; this, however, is the same as given in the table above, and is absolute or "highly concentrated." The constitution of aldehyde has been given in Chapter XIV., and what it really is in nature, Thomson tells us on the authority of Doebereiner, who was the first to notice it, or more especially of Liebig, who found that it could be obtained from either alcohol or ether, and describes it to be a colourless volatile liquid, limpid like water, combining with it in all proportions, the combination evolving heat. Thus alcohol becomes aldehyde at a low temperature unless properly restrained, and the latter spontaneously works its own destruction by latent caloric, though "its volatility is much diminished when it is combined with water or alcohol," and though "it takes fire readily, and burns with a pale flame which emits a good deal of light."

Now that the composition of aldehyde is known, as Thomson truly argues, we can easily ascertain the truth of the facility with which oxygen converts it into acetic acid; for

Acetic acid is . . . . $C.^4\ H.^3\ O.^3$ and
Aldehyde is . . . . $C.^4\ H.^4\ O.^2$

So that if oxygen combines with one of the atoms of hydrogen and turns it into water, and if another atom of oxygen at the same time replaces the hydrogen, the aldehyde will obviously be converted into acetic acid,

and that alcohol and aldehyde differ between themselves only from the former containing two atoms more hydrogen than the latter, is equally obvious; for as shewn above, at page 420.

Alcohol is	. . . . .	$C._4\ H._6\ O._2$ and
Aldehyde is	. . . .	$C._4\ H._4\ O._2$

How easy, then, is each dangerous transition, and how carefully ought favouring heats to be avoided! And moreover, the fermenter may fall into another dilemma; for "an atom of aldehyde, to be converted into *aldehydic acid*, requires to combine with one atom of oxygen. Hence aldehydic acid is composed of $C._4\ H._4\ O._3$, differing from acetic acid merely by containing an additional atom of hydrogen." So far Thomson in pursuing Liebig; so that it is intermediate to the two; and according as the management is good or bad, we have the following products in succession:

Ether	$C._4\ H._5\ O.$	atomic weight	4·625.
Alcohol . . .	$C._4\ H._6\ O._2$	. . . . . .	5·75
Aldehyde . .	$C._4\ H._4\ O._2$	. . . . . .	5·5
Aldehydic acid	$C._4\ H._4\ O._3$	. . . . . .	6·5
Acetic acid .	$C._4\ H._3\ O._3$	. , ...	6·375.

From the volatility and limpidity of aldehyde, it is presumed that spirituous liquors which rapidly effervesce when unstopped, are of an aldehydinous character, and that the acidity which speedily ensues is aldehydic acid, the subsidence of the effervescent action having removed its suffocating influence; and so nearly is it allied to acetic acid, that the flavour of the one can hardly be determined by the palate from that of the other, though aldehydic acid, were it to remain such, would be the sharper and more spirituous alegar of the two: not *vinegar*, for *that* is made from *wine*. *Gar* is Saxon, and signifies *sharpness*, and hence by interpretation a *lance*.

The variable conditions and the tendency of our malt liquors to decompose, originate chiefly with the commencement of the fermentation; for then it is, if not earlier, that the seeds of acidity are sown, and their developement becomes more conspicuous as heat, their *primum mobile*, increases. During the first part of the fermentation, some of the most soluble of the ferment becomes blended with the water or the alcohol, or both; and the acetic acid first formed aids the solution and incorporation, the latter often originating from a surcharge of oxygen on the coolers, and being frequently the primitive cause of early acidity where the mash has escaped free, especially in summer-brewed beer: a circumstance to which those who use refrigerators, with a plentiful supply of cold water, are far from being so liable.

Thus we see that our malt liquors which are brewed and stored under those that are deemed the most auspicious circumstances that can attend the current system, if an unsystematic process can be so termed, where we suppose that the heat has not at any time exceeded 60°, are liable to become acid, all the destructive agencies being thereby induced, retained, and active, till the very alcohol, whose nature it is to preserve the richer parts and to impart strength, is subject to change and become alegar, the intermediate stages being imperceptibly hurried over. This spoliation, as a matter of fact, is too well and too sorrowfully known both to the producer and to the consumer, and how to avoid it is the anxious enquiry of all; for as no effectual remedy has yet been provided, the work of destruction still goes on; but its course, according to the sanguine hope and certain expectation of the author, is nearly run, which his disciples now likewise foresee. A little more time

and patience, with the establishment of a more general faith, which conviction alone can produce, and its career is destined to terminate for ever,

> "And, like the baseless fabric of a vision,
> Leave not a wreck behind."

That is, if the public can be persuaded to dissipate old-fashioned prejudice, to scatter fear and doubt to the wind, and to listen to the plain-dealing language of reason and experience. Let us hope that the evidence here given will beget new convictions in the minds of the studious and enterprising, make more converts to well-grounded opinion, and for the community's sake rather than our own, as well as for the prosperity of individuals, enlist proselytes to the new system.

Gluten being a vegetable organ, almost like albumen in its nature, and as such, being exceedingly subject to change, that change is attended with most disastrous consequences to the vital property of every thing around it, particularly the alcohol, provided this alcohol be at a temperature which will submit it to the influence, namely, at any heat above 52°, as indeed it almost always is after the fermentation commences, so that as the sugar transmutes into alcohol, the gluten assists in converting it into acid, and as the heat advances, so is this acidifying process accelerated. Hence we cannot do otherwise than infer, that if the fermentation be commenced above 52°, the first drop of spirit is liable to the attack of the oxygen presented to it by the decaying yeast or gluten, or otherwise, and that such is actually the case, shall presently be most satisfactorily proved. Let the least sceptical put his worts to the following simple and fair chemical trial.

Just before pitching a wort, if it have been expedi-

tiously cooled, as soon as it is down at 70° or below, dip a bit of blue litmus paper into it, and if the colour of the paper remain unchanged, no acid is present. After the same wort has been pitched, and when the fermentation has commenced, the same test may be applied again, when the acid then being formed, will tinge it with spots and streaks of red, and as the fermentation proceeds, the more will the attenuated liquor redden the test-paper; indeed, the natural carbonic acid will slightly affect it, but not so much as when acetification has set in. Thus any person can easily detect the presence of acids, and the period at which they are formed, and so convince himself that by the existing mode of fermentation, the two distinct processes of vinous and acetous working are going on in the vessel at the same time. That the precious alcohol is the victim of this turbulence, the following rational and learned conclusion from Donovan's treatise in Lardner's Cyclopædia, may tend to shew, though not coincident with fact:—

" With regard to the theory of acetous fermentation, and the formation of vinegar, or acetic acid as it is called, in its pure form, little is certainly known. It may be admitted, as a fact, that it is almost exclusively the alcohol of the fermented liquor, which is changed into vinegar, and the question is, what is the nature of the change? Lavoisier, finding that the oxygen is absorbed during acetification, concludes that its presence and absorption are indispensably necessary; that the oxygen enters into the composition of acetic acid; that acetic acid is *plus* oxygen; and that the change effected by the acetous fermentation does not enter into combination with the alcohol, but acts the very different part of abstracting some of its carbon, combining with it, and thus forming carbonic acid, which then remains a separate compound, either exhaling or remaining mechani-

cally mixed with the resulting liquor. From the facts ascertained by Saussure, it might be supposed that nothing happens in the acetous fermentation, except the abstraction of carbon, and that acetic acid is alcohol *minus* carbon. But that this is the case, a very little consideration will suffice to show." This certainly accounts for the utter destruction of the alcohol, though not on correct principles; for instead of abstracting carbon, we have shewn from the more modern and minute discoveries of Liebig and Doebereiner, that this element remains unchanged throughout the several transitions, and that the abstraction is of hydrogen in interchange for oxygen. The learned Irishman proceeds to give the following, which are here arranged tabularly, that they may be the more readily seen and compared.

Primary elements.	Acetic acid.		Alcohol.
	Gay Lussac.	Berzelius.	Saussure.
Carbon	50·22	46·83	51·98
Oxygen	44·15	46·82	34·32
Hydrogen	5·63	6 35	13·7
Total	100.	100.	100.

He then takes Berzelius's analysis of the acid, which contains the smaller quantity of carbon, and compares it with the alcohol, which thus gives 5·15 as the decrease of carbon obtained by the change; and says, "*Supposing* that the oxygen absorbed by the fermentation, which turned the alcohol into acetic acid, to have combined with and carried off 5·15 parts, the result would be, C. 49·362, O. 36·183, H. 14·442," which, he asserts, "is very different from the composition of *acetous* acid, as represented by Berzelius." But at all events,

Berzelius's carbon agrees, and the remainder of the oxygen in excess is made up from the hydrogen, which also appears to be the case, and to a greater extent, in Gay Lussac's analysis. Saussure's is almost identical with that by Liebig, as given in our 14th chapter; but any carbon which they obtained must have come from a portion of the sweet which had not transmuted into alcohol. Gay Lussac's diminution of carbon is exceedingly small, so that the Doctor has made some mistake in his calculations, and doubtlessly from a wrong impression; and it is rather strange that he should not have seen his error, and examined his figures, when he admits at the same moment that "Vauquelin conceived that *the ferment* takes both hydrogen and carbon from the alcohol, leaving therefore an increased ratio of oxygen, and thus converting it into acetic acid, while ammonia and an oily substance are formed; but the production of these two compounds seems not to have been ascertained." In these several analyses something depends upon the purity of the alcohol, as we find Doebereiner employing it at a sp. gr. of 863 in preparing *acetal*, and Pelletier as low as 815 in various experiments on quinine. Our analysis of *absolute* alcohol, at page 420, very nearly agrees with Berzelius again; and there aldehyde is shewn to contain 7½ *per cent.* more carbon than here exhibited, and ether nearly 18 *per cent.* from the same four atoms; and why? Because there we had fewer atoms of the weighty element, oxygen, in proportion, which accordingly gave the carbon a greater comparative preponderance, and consequently the *per centage* may alter without any abstraction of carbon whatever; a circumstance which has not struck the learned Doctor of the Cyclopædia; therefore, after much reasoning, he is satisfied with saying that, "in

the absence of facts, hypothesis may be substituted. After some consideration, I feel inclined to the following explanation. Perhaps it is near the truth to suppose, that in the formation of vinegar, the constitution of the alcohol is subverted; that the elements of the latter re-combine in such a ratio as to produce vinegar; and that the residual quantities of the elements not required for the vinegar, unite and form some other compound." On a hypothesis thus vaguely conceived, he elaborately proceeds to build a sèries of new conjectures, one upon another, and at length comes to the final determination, that "oxygen is not necessary to acetification;" and that "therefore an explanation of acetification need not to be embarrassed by accounting for a phenomenon which is not a part of the process to be explained." The editor of Chambers' Information, Part XIII., has been better informed on this subject, having alcohol C. 51·98, O. 34·32, H. 13·7, or to mere fractions of the *quanta* given by the eminent analysts above-named, and quoting Saussure.

The formation of the carbonic acid, which becomes gas, is thus otherwise accounted for in Thomson, who says, in his Chem. Org. Bod., p. 8, where he treats on the theory of ethers, that a discussion respecting the constitution of ethers had then been carried on between Liebig and Dumas, with much animation on both sides; that, according to the former, the radical is $C.^4\ H.^5$; but, in the view of the latter, $C.^4\ H.^4$; and that, "of the two," he is inclined to prefer Liebig's doctrine as the simpler, and more agreeable to the phenomena. He then follows that philosopher in resolving sugar as follows, only we halve his double atom to simplify the result:—

"Common sugar is . . . . $C.^6\ H.^5\ O.^5$

Now it is resolvable into

1 atom ether	$C.^4\ H.^5\ O.$
2 atoms carbonic acid . . .	$C.^2\ \ O.^4$
	$C.^6\ H.^5\ O.^5$"

Which shews at once the dissipation of all the carbon that disappears, and the fountain and creation of the carbonic acid gas and ether, prior to the formation of alcohol from the latter, or from the body. The elements, therefore, reduced to a table, are thus disposed:—

Primary elements.	Sugar.			Ether.			Carbonic acid.		
	Atoms.	Equivalents.	Per cent.	Atoms.	Equivalents.	Per cent.	Atoms.	Equivalents.	Per cent.
Carbon ..	6	4·5	44·44	4	3·0	64·87	2	1·5	27·27
Hydrogen	5	0·625	6·17	5	0·625	13·51	–	—	—
Oxygen ..	5	5·0	49·39	1	1·0	21·62	4	4·	72·72
Total ..	16	10·125	100.	10	4·625	100.	6	5·5	100.

That is, considering each as a compound consisting of 100 parts *in se;* but taking the acid and ether as mere components abstracted from the sugar, and filling its volume between them, the result is, that 29·63 *per cent.* of carbon remains in the ether, ready to form alcohol, and 14·82 *per cent.*, or just half as much, supports the acid, and is carried off in gas; that the whole of the hydrogen, or 6·17 *per cent.*, lapses into ether, and is insufficient to support the after-change into alcohol; and that no more than 9·87 *per cent.* of oxygen passes into the ether, whereas 39½ *per cent.* of that element gives

way to the carbonic acidity; that alcohol requires a fresh supply of as much more as ether, and that the ethereal quantity is tripled before the acetic acid assumes its birth and sovereignty. Who, then, can say that oxygen is not an essential supporter of acidity? This is a studious subject, but is very serious in its consequences; and Booth's *demon* is a real being, which, joking apart, is more to be dreaded and guarded against than all the witchcraft and thunder which excited the blinks to frighten old women before Richardson broke the spell of incantation by the introduction of his saccharometer!

Furthermore, the elementary exposition of alcohol already given, as deduced from Liebig, agrees to a fraction with that observed by Saussure; and we are bound to consider that the nicety of the analysis is subject to the height of rectification to which the spirit has been brought; and on comparing the sugar here with the acetic acid of Gay Lussac, that farther and final transmutation, and the supposition that both are correct, would appear to have had the effect of completely interchanging the carbon and the oxygen, were it not that now we see the *ultimatum* of the former; the hydrogen acquired by the conversion into alcohol being transferred from its duteous connexion to assist in forming the acid, thereby entertaining a species of fermentation in many respects diametrically contrary in its action to that vinosity which it conquers and destroys.

Acetic acid, in common with alcohol and their parent sugar, has its different degrees of perfection, and each is dependent on concomitant accident, as well as direct lineal derivation; for as great a difference may obtain between acetic acid formed from alcohol in its intermediate state, and that obtained directly from the root of sugar, as Berzelius's and Gay Lussac's analyses ex-

hibit, and even more, aërial and elementary contagion and temperature being especially considered in the computation: in fact, anhydrous acetic acid may be as low as 1010, according to Liebig and Gregory's Turner.

That alcohol, therefore, is convertible into vinegar, and is propense to the change, no doubt can longer remain in the experienced mind. Cartheuser, Chassieur, De Machy, and others, recommend that this spirit be applied to vinegar by persons desirous to improve its acid strength. Thomson has a remark, that the presence of an acid was formerly supposed to be essential to fermentation, but that it does not *seem* to be the case. It is true, indeed, that an acid *usually* makes its appearance in fermentation, he continues, but its formation *has been* attributed to the action of the yeast upon the starchy and mucilaginous parts of the wort, though from what he believes through Fourcroy and Vauquelin, it does not fail to appear where yeast is not used in the process. This, then, to him is all conjecture; but the following is more decisive, and applies at once to the point at issue:—"The gas which comes over consists of half carbonic acid and half hydrogen; but at a lower temperature pure malt wort does not yield any inflammable gas." (Chem. vol. iv. p. 379.) Who, then, would keep up the temperature of the wort to destroy its spirit? We have seen and proved that the abstraction of hydrogen annihilates the alcohol.

Thus we every where see that a cool fermentation is slow and vinous, causing the yeast to subside to the bottom of the vat, and the body of the liquor to retain the gases which produce spirituosity and future briskness, and that they lie dormant till called into future action; but that, on the contrary, heat drives the musts to ferment rapidly, to exhaust their stimulus by overexertion, and to float over the tops of the vessels, to be

used for any other purpose than that of preserving the beer; and that consequently the alcohol really furnished in support of the saccharine nutriment, becomes an immediate prey to the first invading foe, and all the good that we have been striving to accomplish, is liable to be dissipated and rendered null.

Let us now consider the old prime beverage called "stingo," which flows so freely in the halls of many who deserve the title of "fine old English gentlemen," and there we shall find it in perfection, not because it has been attenuated by force and chemical skill, but because it has been fermented carefully, and stored in the best, the deepest, and the coolest cellaring that the builders of the mansions could devise; and this is of itself a guarantee, without any recourse to hypothesis, which is too speculative for conviction, that British beer thus prepared, be it of the ale or porter species, will withstand the baneful influence of the atmosphere during a whole age, provided that it have been well matured in the cool vault. Of this kind were the "Morocco," at Levens in Westmoreland, particularised in the former edition, which was never tapped under twenty years old, and the "Mum," twice named by Booth, which our ancestors brewed from oat malt, and tapped after standing two years, but which, as he observes, is "now unknown in England:" this beer was never hopped, or impregnated with any bitter. It appears somewhat strange that Dr. Ure, who has undoubtedly read the Diffusion of Knowledge Society's Treatise, and swallowed many of its contents, should leave out of his catalogue of German beers that of Augsburg, "which is so famous *throughout* Germany," in which, when stored, the dried roots of the common hedge-plant Avens or Herb Benet, "highly extolled all over the continent," used to be suspended sliced in a thin linen bag,

and to impart a peculiarly pleasant odour to the beer, which when "so managed *never* becomes acid." This, however, seems to be a preservative rather than a restorative; and if we admit the justness of the proverb, that "it is easier to prevent an evil than to cure it," we must go to some cool calculating butler to a British nobleman or gentleman, who brews at the birth of his master's heir, in the hope of having the felicity to broach his own bunging on the day when the said heir shall attain his majority of twenty-one.

Stuff like this outvies that celebrated British wine which the yore Romans took home with them as a kind of trophy, and exhibited before the senators as a captured treasure, "superior to all the wines of Rome;" and that was it which inspired the heroic followers of Caradoc, Boadicea, and Cymbeline, and which fed the mighty Constantine, son of Helena and grandson of Cole, and the greatest champion whom Christendom ever had, (whatever the wine-pampered chivalry of the Norman ages may say to attempt its disparagement,) for *this* is the article that, so long as the "brain-spattering, windpipe-slitting art" exists, should go forth with our fleets and armies into the uttermost parts of the East, and as far as British avarice, madness, tyranny, valour, or "cruel necessity," carries its sway over the face of the earth; and the argument is sound, namely, that it will *keep*, and it suits every constitution not broken by disease, as an invigorating stimulant to enterprise in arts and arms; philanthropy, philosophy, and philharmony; love, learning, life, and LIBERTY!

CHAPTER XVII.

PORTER.

ORIGIN, NAME, AND HISTORY — OLD ENTIRE — DUTIES AND ALTERED CIRCUMSTANCES — BROWN STOUT — LONDON BREWERS — ADULTERATIONS AND DECEPTIONS — SCOTCH FRAUDS — ENGLISH LAWS — BOOKS — EVILS OF BLACK MALT — CAROMEL — LONDON AND DUBLIN — TABLE OF GRISTS — VATTING — LEGITIMATE FLAVOUR — URE'S DELUSION — PALE BEER — CONSTITUTIONAL PROPERTIES — AFRICAN GUMMY DIET — THE FACULTY DECEIVED.

This species of malt liquor, though held in great request in most places, and especially as a cooling draught in summer, is not of ancient origin, but owes its name and character to accident, and its history to adventitious circumstances which have occurred in variable succession. To persons who have lived in London, it is quite unnecessary to mention that the metropolis is the grand mart for its consumption, the natives still denominating it *beer;* whereas in the country it is scarcely any where seen except in summer, when warm; and though gradually becoming more common, till in some parts its price has fallen from exorbitance till it is lower than ale, yet such is the force of habit, that the rustic palate still regards it as a luxury adapted to entertainment, or perhaps to medicine, rather than to ordinary use.

According to the Society for the Diffusion of Useful Knowledge, or the authority whom their editor has quoted, the Londoners, as well as the Scotch people, had three qualities of malt-liquor, distinguished as ale, beer, and *twopenny;* which last was in Scotland a *pint,*

containing nearly *two English quarts*, till the establishment of a court of exchequer, under an article of the union with England in 1707, subjected the Scotch loomer to a license or a penalty; besides which, a heavy tax was put upon malt, so that the Scotch guidwives were obliged to bree sae thin, that their customers deserted their bens, and the fairies "ran e'en awa' with the twapenny." In London a very different fate befel it; for the people there, having accustomed themselves to indulge in "half and half" and in "three threads," till they found that these admixtures could not be relied on as halves of each of the better, or exact halves of any kind, or as equal quantities of the three, an ingenious brewer, named Harwood, contrived, about 1730, how to brew a liquor *all one way*, which should have the conjoint flavour of the whole three *threads*, and be but one trouble to the tapster, which production he termed "*entire butt.*" His scheme succeeded admirably, his business expanded, and, say they, as his was "a very hearty and nourishing liquor, it was very suitable for *porters* and other working men; whence it obtained the name of PORTER." This tale is otherwise told by some, and the subjoined version appears the more rational and credible of the two. A rumour has been handed down to posterity that Harwood, being an obliging man, had his beer *ported* or *carried* round in pots and pints of pewter, upon *racks* or cratches, and left at the houses of his customers, as is still the metropolitan practice; and that his potboys cried "Porter," as they knocked at the doors; meaning not the beer, but themselves *as its porters*, till one became identified with the other.

Scarcely does this our beer-sipping country contain any two brewers, particularly neighbours, whose productions are alike in flavour and quality, and especi-

ally in the article porter; for even in London, a practised connoisseur can truly discover, without hesitation and by mere taste, the characteristic flavour that distinguishes the management of each of the principal or neighbouring breweries; and a more striking difference still is discernible among some of the Dublin houses, none of which yield a flavour like country-brewed porters, many of which are shockingly bad, being sometimes blinked, often tasting of empyreum, some black, some musty, some muddy, some barmy, and some having the predominant taste of Spanish juice, which is not an uncommon ingredient, and generally speaks for itself when taken upon a delicate stomach. This diversity is caused by a variety of circumstances, known and unknown, as some of them are profoundly veiled in secresy; but at present as much from the colours and proportions of the grists brewed, as from any other general cause.

Besides its peculiarly agreeable flavour, Mr. Harwood's production had an inviting brunette complexion and a mantling effervescence, giving it a spumous "cauliflower" head, when poured from one vessel to another, or otherwise agitated, which distinguished it so far from all other beers then brewed, that though no other competitor of that age could produce any thing at all to vie with it, all were alert to imitate it, and were aware that it had the advantage of age. One brewer (Thrale), imagining that it had the smell of oak, in which he was not mistaken, and knowing that newly manufactured oak timber imparted a brown tinge from the tannin which it contained, had his store vats made of this material, which answered exceedingly well; and this, together with experiments in browning malt, to which process the Hertfordshire and Berkshire maltsters were speedily alive for their own benefit, led to the

establishment of the porter trade as a lucrative city and suburban monopoly. Drying the malt with *fagots*, or *pieces* of *beech* (from *fagus*), and bavins, or *billets* of *birch* (from *betula*), had long been known to deepen the colour of malt, which to the admirers of straw-pale ale had been an eyesore, but which now converted expediency into virtue, and by those whose convenience it suited, or to whom a little expense was not a considerable object, recourse was had to oak, the smoke of which fixed a still deeper brown and stronger flavour. In the meantime, the more fraudulent of the malting fraternity, ever accustomed to extort, found that the process of browning their ill-harvested and imperfect barleys, hid the stains and other blemishes, and the blowing system also became prevalent; and here a trick may be noticed, which is not mentioned at page 90 above, which is thus played at the expense of the workmen's health. Before the first sweating of the malt upon the kiln has subsided, they throw it into a heap for 24 hours, to give a last forced impetus to the germs, replace it upon the kiln with a strong fire of wood under it, and again turn it two or three hours, as before.

Malt thus blown was for a while greatly in demand, from its giving a "flush" to the porter brewed from mixtures of this and others; but the brewers found that the deficient yield of these fictitious malts would not maintain their prices, unless the extracts were made *thinner* by spinning out the lengths; therefore, some of the London capitalists determined upon manipulating none but the soundest barley, browning it in the most improved manner, mashing with it a quantity of the best pale or amber, according to relative taste; selecting the best matured brown hops for the maintenance of the beer, and each adding likewise his little secret chemical preparation to modulate flavour and excite

effervescence. As the very best brown malt was found to be defective in its produce, when compared with pale of the same growth and steep, the more affluent made up the deficit by stronger mashes, less attenuation, and longer vatting, by which means they prepared a stronger body, which they sold at a price greatly advanced above common porter, and gave it the appropriate name of Brown Stout.

Brewers were not aware of the full extent of default to which their malts had been reduced by browning and blowing for porter, through the heat at which they had been dried, till the introduction of the saccharometer (*vide* p. 215) detected the absolute amount of their loss, and declared it to be from 20 to 25 *per cent.* in blown malt, and from 16 to 20 *per cent.* in the best brown, in comparison with pale (*vide* p. 170); and, in proof that these indications were true, they discovered, through the agency of the chemist, that their good ales would analyse 8 *per cent.* of alcohol, but that their best porter would not produce more than 6½; and then it was that the immense profits realised by the maltsters made the brewers of "common" bestir themselves in devising better means of self-protection than the loss of their trade, through the lightness of their mashes, was likely to afford. Wits went to work, foreign ingredients were slily recommended and snugly embraced, the herbals were consulted, the mariners rewarded, the druggists enriched, the trade lost its reputation; and Government, taking advantage of the overstrained ingenuity and contraband intrigues of the traders, not now confined to London, or yet to the porter department, levied an enormous additional duty on malt.

The year 1798 gave birth to Richardson's "Philosophical Principles of the Science of Brewing," in which he recommended socotrine aloes (*aloë succotrina*) for

flavour, salt of steel (*vide* p. 115,) for a "retentive head," and afterwards quassia (*vide* p. 254) instead of the former, and copperas or sulphate of iron as superior to the latter, the *green* mineral being greedy of oxygen, which converts it into *brown*. For malts, he informs us, that his usual blend was in equal quantities of brown, amber, and pale; or when the porter was to be sent to "a country where its production is novel," he preferred mixing two parts of brown to one of pale, omitting the amber. Whether the above or similar innovations led to the interference of the legislature, little doubt can exist, as the tax was imposed in 1802; after which we read of numerous additional expedients to evade it, which the brewers chose as indemnification against increased risk and exigency. Liquorice-root (*Glycyrrhiza glabra*, *vide* p. 33) was one of the most prominent adulterations, both in powder and as manufactured into black Spanish juice; and molasses, sugar, and raw grain (for which *vide* p. 167) took the place of malt; black resin (*resina nigra*) was picked out as a flavourer, and when mixed with finings that would float, as a shield against the admittance of atmospheric air; and marsh trefoil (*vide* p. 244), bitter or shrub quassia sticks (*quassia amara*, *vide* p. 247), and more largely the chips and rasped bark of the tree quassia (*quassia excelsa*, *vide* p. 253), with alum (*alumen liquidum*) to clear and heat it; and gentian, or bitterwort root (*gentiana officinalis*, *vide* p. 247), all became substitutes for hops; and as narcotics, to end the catalogue, tobacco (*nicotiana*), bitter bean of St. Ignatius (*fabamara Ignatio*), is recommended in several brewing treatises; and though perhaps at first in mistake for buck or *bog* bean, seems to have led, through ignorance, to the importation of the bitter *nut* (*nux vomica* or *strychnos*), which last are poisons in a rank degree, ad-

mitting no pardon or excuse whatever, more especially as all drugs were interdicted by the statutes. (*Vide* p. 246.)

We must not attribute these vicious preparations to the porter trade alone, though the immoderate length to which the impositions were carried out led, after their discovery, to a relinquishment of porter-drinking by many, and to a consequent stagnation in the trade, though the ale brewers were not less guilty, entertaining raw grain, sugar, gentian, quassia, and alum, with equal temerity; besides which they mingled salt, to chase the fox; honey (*mel alveari, vide* p. 115. 167) as a saccharine sweet and preservative; jalap (*yalapæ pulvis*) to prevent acidity, and to counteract the effects produced by the heating India berry (*cocculus Indiacus*), or by decoctions of the sliced root of sweet flag (*calamus aromaticus*), with carraway seeds (*carum carui*), and those of coriander (*coriandrum sativum*), which were infused ground, to act as a cordial; and another consisted of the powders of the following, or some of them, boiled with the wort; orange peel (*citrus aurantium*), long pepper (*piper longum*), Guinea pepper (*capsicum annuum*), grains of Paradise (*amomum grana Paradisu, vide* p. 14), and ginger (*amomum zingiber, vide* p. 14. 245). Hartshorn shavings were boiled in "the best London ale," to fine it; and in some breweries marble dust, crabs' claws, oyster-shells, and egg-shells, were pounded as carbonates of lime (*vide* p. 109. 112. 117), when that mineral was not native in the water, were put into the ale as anti-acids, after it was brewed; and the subcarbonates of potassium, magnesia, and soda, were added, as they still are by some, to soften down a sharp acid before drinking. Sulphate of lime (*vide* p. 113, 114) was to prevent fretting; and lastly, opium, and a compound nostrum called *multum*,

containing opium and other matter, was sold by the druggists to create strength and a drunken sleep. All these had their run, with greater or less comparative success, according as the taps satisfied, and the deception continued; and the sale of all these, or the most of them, constituted the staple of the brewers' druggist, who travelled from town to town to dispense his boons for the "benefit!" of the community. Nor did e'en the cannie Scotsman, whatever his defence, escape the contamination; for though "the Edinburgh brewers have been less the prey of travelling druggists than their brethren of the south," yet "*a little* honey to add to the sweet, and *a few* coriander seeds or *other aromatics* to assist the flavour, are, as far as we (the Useful Knowledge men) have learnt the amount of the sins of which they have been accused," they have not been altogether guiltless, nor, perhaps, were their malefactions so narrowly watched. We may agree with them upon the hardship, that "while the excise officer shall be threatening or prosecuting a brewer for putting a quarter of an ounce of sulphate of iron into a barrel of his *porter*, another brewer, under the survey of the same officer, shall have ten-times that quantity dissolved, naturally, in the water which supplies his brewhouse!" (Treatise, p. 20.) And then it was *very* hard upon a poor Scotchman, that "*if* the substitutes were not more noxious than the principal, and some of them were less so, the conscience of the brewer was easily satisfied; especially seeing that he could procure as much bitter for sixpence as would otherwise have cost him a pound." (P. 27.)

Now this may be the identical reason, or one of them at least, in prominent conjunction with the train above, why the legislature interfered; for the practice of adulteration had been carried so far in 1810, especially in

brewing fresh raw grain and from sugar, that, notwithstanding the tremendous charge put upon malt by the Excise, the malt revenue for the ten years then expiring amounted to an average (*vide* p. 103) of more than 28 millions of bushels less than in any of the three preceding equal periods, being a diminution of 9½ *per cent.;* Scotland alone having yielded less by 6 millions and odd out of 17 and odd, being rather more than 34¾ *per cent.* Well, therefore, may Scotch writing brewers boast of their countrymen's honesty under temptation, and insinuate thus! "The immense capitals and influence of the ten or twelve principal (London) houses defy all competition, and whatever malt liquor they agree to designate by the name of porter must eventually pass current with the multitude. This is no random assertion; for it is well known that the liquor now retailed under that denomination has little or no resemblance (in 1827) to what was so called thirty years ago." In the eye of this scribe, therefore, the principal Londoners were as roguish as the Burton men (*vide* p. 114,) and no doubt were *equally* culpable; but, without presuming to determine upon this point, Government being aware of the nefarious practices existing at the period in question, passed an act of Parliament in 1811, containing certain prohibitory clauses against the practice of mashing with raw grain or sugar, allowing the latter only in its concentrated state of *essentia bina* (*vide* p. 90) as a colouring material for porter; which act had the effect of increasing the English revenue, but not the Scotch, or yet the national aggregate (*vide* again, p. 103), for "the *more scientific* brewers were enabled to save two-thirds of the malt duty, and consequently gained an advantage over their less knowing brethren." In 1812 (*vide* p. 169) sugar was again permitted to be used.

In the season of 1812-13, hops rose from £5 to £15 *per* cwt. and remained at £8 or £9 till 1816, when they ran up to £14, and in 1818 as high as £31; though meteorology does not shew (*v.* p. 329-30) that any thing remarkable happened to the harvests of all those years; but in 1816, as the duties did not increase, parliament again interposed, and put down all ingredients in the brewery except malt and hops, and the following year brought out Mr. Wheeler, as noticed in a former chapter (*v.* p. 90). Yet with all these enactments to suppress fraud and protect the people's lives, there has been, through the publication of books or otherwise, "a general complaint of the declension of the quality of London porter," or at least of its character. Who can be surprised at this, when, eight years after the last-mentioned act became law, we can find "a brewer of thirty years' practical experience," recommending that to each hogshead, "generally speaking," there be added "capsicum ½ oz., ground and used in the copper; cocculus Indicus 1 oz., must be bruised, ditto; liquorice 4 to 8 oz., either dissolved or dropped by single pieces into the copper in full boil; salt of steel rather less than ½ oz, dissolved, and added on sending the porter out; colouring 1½ pint. If porter is put into vats, then will be the "proper place to use the colouring, if not, then in the tun;" and in a specimen of "the process" likewise naming an indefinite quantity of "galls" for colouring! We had heard of galls being used in France, but not here.

The reasons assigned by that writer, if they deserve the name of reason, for the continuance of these forbidden commodities, are unsatisfactory, and in some respects unwarrantable:—"Spanish juice imparts *colour* as well as flavour and considerable richness, fictitious strength from the use of the cocculus Indicus berry, sen-

sation of warmth by capsicum, and a fermentation is produced by salt of steel, which brings a fine head, giving a peculiar colour by striking a dead brown with the astringent matter of "the hop:"—but why colour with *both* this and liquorice? or why use either, when a better might have been found in *essentia bina*, which was obtainable at the same risk, and was "merely the sugar of which the *colour* is composed, more highly calcined, so as to become a *very* dark brown, and exceeding bitter?" And why brew with cocculus, which, "if taken in too large a dose, will occasion severe pains in the head, vertigo, and distressing sickness," and when if that which is "contained in a pint should occasion any degree of inebriety, the individual who sits by his side, and drinks a gallon, may pay the forfeit of his existence?" And all this in 1824, when the extract of cocculus sold at a guinea and a half *per* lb., though about the time of passing the act, "the numerous body of quacks, who called themselves brewers' druggists, were almost annihilated by exchequer prosecutions;" and though so lately as 1827, "seizures and convictions had continued to be made, and were still making by the excise," yet we find the very Scotch writer who then complained of the conduct of the "reckless beings who used deleterious ingredients," urging breaches of the law, by prescribing in one place loaf sugar, in another salt, salt of steel and sulphate of iron, and black rosin with half-spent hops; in another *essentia bina*, aloes, and quassia; in another horse-beans and egg-shells; and in another honey, over the prohibition of which, especially, he laments most pathetically, because, though illegal, it is not deleterious. "It is melancholy to see its expiring efforts in the excise accounts for 1808; the gross actual receipt in money for duties on *metheglin* or *mead* is there stated to have been *one pound, eleven shillings, and six-*

pence."—Yes, just the price of a pound of expressed cocculus, which this writer describes as "a strong narcotic it is doubtless; for it is on that account alone that it has preserved its place in the brewery;" but he gives a similar account of hops, which he pronounces "astringent and narcotic," decrying by word, measures which he was encouraging by deed. So much for consistency and the interference of the law! The Scotch malt duties, which then barely covered a million of bushels annually, have of late years, since the suppression of illegal traffic, averaged more than four millions (*v.* Table, p. 104). Down with the abomination!—Perish the idea of a man covertly condemning that which he overtly commends! The author's sentiments with respect to this subject stand expressed in a former part of his work, (*v.* p. 247-8,) and he is not disposed to put his hand to the plough and afterwards to shrink from cultivation.

Disregarding, then, all absurd notions of any gain in purse or character from the adoption of spurious policy or illegitimate infringement, the best mode of brewing *genuine* porter is the matter now for consideration, since the very same brewers, whose principles lead the whole fraternity into jeopardy, admit that "exceedingly good porter may be brewed from two sorts of malt only." It is ridiculous to say, as some have done, that vinosity is not requisite in porter so much as potency, or yet to argue in favour of fulness without spirituousness; and it is more ridiculous still to assert that "flavour is little studied" in the porter brewery, or that "the hops usually employed in brewing that beverage are either coarse or old, and would not be admissible in fine ales," as though the porter brewer were some despicable creature, who would put up with any thing which his superiors spurned. The criterion is, the malt should be sound and very well dried; and the hops strong and

sufficiently matured in their growth; but not *coarse*, as some express it, nor yet very *old*, as it is well known that long keeping entirely deprives them of their virtue; and let this suffice for qualification.

The temperature of the mashing liquor for porter grist has by some been a subject of grave consideration, while with others it is taken as mere custom and example. The old and erroneous idea that the brown and amber malts are in greater danger of setting, and consequently that they require colder mashing than the paler kinds, is now being abandoned, and the reverse belief having begun to prevail, a more correct practice has been introduced, and is becoming general. The effect of much fire under the kiln not only gives colour to the farina of the grain, but in some cases so far destroys the diastatic gluten by charring, as to render it inoperative in the mash-tun; while in other cases, the previously formed sugar is deprived of its sweetness by excessive heat: this satisfactorily accounts for the apparent deficiency in the extract of malt, (*v.* p. 151-2, and p. 486, above,) in proportion as its colour is deepened by the maker.

When the whole of the grist or malt is subjected to the operation of mashing, the ordinary mode of extraction is often necessarily different from the treatment of pale malts alone, where sparging and as few mashes as possible are practised in the latter case; whereas the pasty consistence and insoluble parts of the high-dried corn require additional mashings to reduce them, and particularly where black malt is employed, by its accumulating on the false bottom of the tun, or amongst the lower strata of the goods, by which the vertical descent and regular process of the worts are impeded soon after each mash, so that the goods as often require breaking anew and remixing, in order to admit of their

equal dispersion and dilution. The chief evil in these repeated mashings, is the saturation of the top and bottom parts of the goods with wort of equal gravity, without the usual advantage of totally exhausting even one half of the grains by the downward washing and filtration afforded by the sparging system ; so that a diminution of extract is the consequence, in proportion to the quantity of the black substitute, and its hordeous or imperfectly malted state.

Allusion has been made in former pages, to the improvement which has of late years been made in the metropolitan ales, (*v.* p. 486,) while on the other hand their beers have, in too many instances, gradually declined in virtue and beauty, which circumstance is not wholly, as we have seen, (p. 491, above,) though in part attributable to the introduction of Wheeler's patent malt, or such as is roasted in imitation of it; the "nappy brown stout" produced from amber malt, having fallen off, and in many houses a black sulky beverage being substituted in its stead, on the taste of which the stranger experiences a shake, as sudden and electrical as that which seizes a spaniel when quitting the water.

This obdurate ingredient, though now considered by many to be almost or wholly indispensable, is often in the porter brewer's way, from the obstacle which it presents, whether mixed among the grist in the mash-tun, or with the hops in the copper. In the latter place it inflicts its penalties by the descent of its insoluble particles, and their adhesion to the bottom of the copper, and particularly if it is of an inferior quality from not having gone through the proper stage of vegetation. In this situation it forms a lining, sometimes of considerable thickness, and obstructs the passage of the heat from the furnace beneath, and the consequence is, that

the bottom of the copper imbibes and retains much caloric; and if the heat reaches to redness, oxygen is absorbed by the metal. In this case, a fracture is commonly first evinced above the *lag* or channel in front of the fire, or wherever the greatest and most rapid contraction of the metal occurs after drawing the fire and introducing cold air: thus are many copper bottoms burnt out through the practice of boiling malt. In some establishments this destructive operation is obviated by the use of steam, and even by rousing machines, which prevent the subsidence of the ponderable matter; but this precautionary measure is not very common. Many brewers consider it more economical to boil the black malt with the worts; but the facility with which both gum and sugar, whatever their colour, dissolve in water of any temperature, shews that the idea is incorrect, as far as the extraction of colouring matter is alone considered.

Of this black or porter malt, as great a variety obtains, both in quality and colour, as in any article of commerce, for reasons already given (p. 90 and 486). The inferior and low-priced, which by some is thence foolishly accounted *cheap*, is mixed with grain that has never properly germinated; and in too many instances very light barley, and even that of a better quality, is dried as soon as the excise officer has taken his floor gauge, and consequently before vegetation has proceeded through one-tenth of its proper course, in order to preserve the form and substance of the corn as much as possible. Thus the malt duty is paid, and the grain is without the advantage of being malted, merely because such mean barleys would become exhausted by the process: this is not rational, nor is the maltster honest to himself or his customers, through its being unsaleable while undisguised. The colour is often so black that it

resembles mere cinders, and the whole corn is puffed up to an enormous size, its shape is destroyed unless secured by fraud, and it adheres together in bunches, through the bursting of the shells and the exudation and fixation of the gummy matter when in the roasted cylinders. This article is never bought by any but the avaricious or the ignorant; for the colour and flavour which it imparts in such a state are deficient and poor, because charred vegetable matter is insoluble in water; and it is also sometimes so very unpleasant to the sight and scent, that no spirited or fair trader will touch it, or have it in his possession: its extract, too, is so unstable that a vat of porter impregnated with its rubbishy particles, will generally, within a few months, lose a large share of its colour by precipitation.

Black malt, properly so called, is certainly a convenient and profitable acquisition in the brewery; yet none but that which has been made from good barley, thoroughly malted, and possessing a sound interior, of an uniform dark chocolate colour, can properly be deemed a good sample deserving public patronage. Besides these characteristics of a genuine specimen, each corn is separate, and as free from excrescences as when it was in the state of raw grain, and as near its original size and shape as the process of its manufacture will permit; and as the greater part of its interior is rendered soluble and perfect by the saccharising power of germination, it contains a much larger quantity of colouring matter of a superior and very desirable kind, consisting chiefly of a species of *caromel*, similar to the colouring matter of former times; being burnt saccharum and mucilage, which impart an agreeable odour to the beer, and maintain its colour with tenacity. The author, desirous to do justice to those gentlemen in the trade who use this new species of

carbonised sugar (caro mellis, *flesh of honey*) as their colouring substance, in moderate quantities, and of the best description, must say, that they consist of all the larger London and Dublin houses and some others, where first-rate talent and liberality continue to exist, and where, as a consequence, none but the best materials are used; and they have their reward in extensive sales, fair profits, and the satisfaction evinced by the public.

The impediments offered to an economical application of this kind of malt in the ordinary way, induces the author to suggest that it would be advisable to mash it alone, in a vessel made expressly for the purpose, and to add the product to the ordinary wort in the under-back, the copper, or the hop-back, in such proportions as the colour of each extract may indicate after experimental mixing for a few moments. On account of the extreme brittleness of the patent malt, it can seldom be cut or crushed without reducing it to powder; and since, unlike other malts, nothing but a simple solution of its caromel and gum occurs when mixed with either hot or cold water, and the whole of the husk and other insoluble particles fall in a compact mass upon the nether parts of the vessel, so that it would be impossible to run the extract through the sediment, as in other cases, the wort which it produces must needs be drawn off from above, by means of taps placed one above another in the side of such adjutant tun: in this way repeated mashings may be had, and the process may be continued as long as any colour can be obtained.

This kind of extract may be cooled, and instantly vatted in its dilute state; but perhaps it would be more advisable previously to boil it for the sake of concentration. In this way several weeks' stock may be kept on hand in good condition, there being no danger of its

decomposition, if kept tolerably cool and free from yeast or other eremacautical matter. It would be difficult to define by words the exact flavour, colour, and constitution, produced by the various combinations of black, brown, amber, and pale, or perhaps to confine the shades of separate malts within these four terms; for the scales of admixture are nearly equal in number with the practitioners themselves. The shades of amber malt, in particular, are so many, and so much difference of colour is imparted by black, that frequent trifling variations are made in the proportions of each by persons who draw out a standard scale for their individual guidance, in endeavouring to arrive at uniformity in colour and flavour, be they such as they may; but by an experienced brewer, this is done with admirable accuracy. The following six, which are varieties in rather extensive use, are here selected as being suitable to the taste and judgment of the author, according to attendant circumstances.

Table of Porter Grists.

No.	Black.	Brown.	Amber.	Pale.	Total.
1	9	0	0	91	100
2	6	34	0	60	100
3	2	30	10	58	100
4	3	25	15	57	100
5	4	24	24	48	100
6	5	0	95	0	100

With those who brew the low-priced shabby article above alluded to, a grist something like No. 1 is used, producing a flavour which would lead a stranger to conclude that liquorice had been engaged in its production, so much like it is the flavour of porter brewed of pale and black malt only, whatever be their relative

proportions. Any fulness which this porter may have, principally depends upon the gum-like portions and properties of the black malt, which, unlike the mucilage of the paler malts, does not submit to the process of saccharisation, either in the mash-tun or in the fermenting tun, and consequently does not contribute to the formation of alcohol: if, however, such an article be strong, and not attenuated too low, but vatted six or ten months, its objectionable flavour is in a great measure dissipated, and a new one is acquired, which renders the potation tolerable, and sometimes really good. Thus porter, made by an excessive use of black malt, is much more mucilaginous than that which is brewed from lower-dried materials.

The destruction of the constitutional principles of corn by a heat more than double, nay, nearly triple the *maximum* which it can withstand, also helps to account for the deficiency of extract from porter malt; for this high heat, which the porter malt has to endure in drying, destroys its diastase, and consequently its generative or converting power, when in the mash-tun. This, and not the double cylinder, has of late started an objection to Poole's patent (p. 89): indeed, the old-fashioned blown, and even some of the ambers, do nothing more than passively *dissolve* in the mash, through having been deprived of their activity by heat.

No. 2 in the above table produces porter of an ordinary kind only, and with a lower flavour than the first, though much superior to it; but its quality greatly depends on attendant circumstances. No. 3 is much improved in consequence of the introduction of one-tenth of amber and a small quantity of brown, or of the deceptive blown malt. No. 4, which perhaps is much more general in the provinces, is preferable to No. 3; and, if used without any counterfeit matter,

gives general satisfaction where the brewer is provided with the necessary plant, proper vats, and a sufficiency of knowledge; but the great misfortune with many of the less experienced country brewers is, that they imagine that porter cannot be brewed from malt, hops, and water, without some other ingredient; and hence they often spoil the flavour of a really good beverage by contamination with liquorice or other alien matter: a fact which, as it demands condemnation, must be admitted with regret. Besides this, country porter is often prepared of a greater gravity than the common London tipple, and is consequently of a higher and ranker flavour, arising from the concentration of its carbonised matter. Country brewers would find their pecuniary advantage secured, and their beer at the same time improved, were they to use newer and better hops than they usually do, and were they to adopt the grist now in use by those whose produce is so much admired by the public, namely, No. 5, and still more so by the exclusive employment of No. 6.

Irish Porter.—The most respectable of the Irish brewers are deservedly noted for the genuine qualities and peculiarly pleasant flavour of their porter; and although some of the peculiarity may be attributed to the fumes imbibed from the drying kiln, and from the choice hops, of which they are not sparing, yet it mainly depends upon the character of their grist. In this respect their practice is similar to that of the best modern London houses, which is the admixture numbered 6 in the above table, or a close approximation to it; and the chief material with the first establishments in both countries is a perfectly malted corn of the finest description, dried to a shade lower than that which is generally recognised as amber malt, the necessary colour being imparted by about one-third or one-half of the black

material required when pale malt is used in lieu of the browner kind. This modern porter malt just described, is dried in such a manner as to cause only very little diminution in the extract, when compared with the paler article, and yields a sufficiency of colour with a desirable flavour, to render no more than a moderate and profitable application of the black malt necessary; and thus is produced a mild, soft, and agreeable potation, of established soundness and permanently good quality.

Some portion of the Irish brewers, and those who rank among the most celebrated, form their grist of pale and best black malt only, first taking the precaution to redry the pale on a kiln kept for the purpose in the brewery, perfect and sound dryness being wisely considered indispensable in malt, and of particularly high importance. To ascertain the condition of any specimen, in store or elsewhere, a hygrometer would be very useful: it is a cheap and simple little instrument, capable of indicating the degree of dampness or dryness of whatever is in contact with it, with promptitude and decision.

London porter, though justly extolled in every part of the civilised world, is not, nor ever has it been, indebted for its superiority, as thousands have imagined, to any particular virtues possessed by the water of the Thames; indeed, it would be very strange if it were so, not only from the disgusting filthiness imparted by its tributary sewers, but from the fact, that the "silvery Thames," as the poet calls it, does not supply any of the London houses with brewing liquor, except they are situated at some considerable distance up the river; and even there the water is pumped up and filtered by the works of the South London and Vauxhall Water Company, at the ebb of the tide, or

at low water, so that those who then employ it may be able to vend it to their customers in the purest state that is possible; for there is not any appearance of "silver" any where below Battersea Bridge, except what a poet's eye can see; and even those who employ this water in the purified manner here described, reject it during the summer months, especially if they have spring wells within their premises, and know how to appreciate them: an acquisition which few are willing to be without, for the above and other good reasons.

The process of extracting the porter wort is much the same as that which has been recommended in brewing ale, with the exception already pointed out, in consequence of a choked mash. Some brewers recommend that porter be boiled 8 or 9 hours to increase the colour, and if of different mashes, to apportion that length of time among them, according to relative strength; forgetting at the same time that "long boiling prevents free fermentation." With the hop-convertor in operation, however, all disputes on that head are laid at rest.

Common London porter ranges from 20 to 22 lbs. *per* barrel, and the ordinary stout for town consumption about 26 lbs.; and stronger than this is mostly sent into the provinces, or consigned to exportation. The different qualities of beers, whether porter or not, are generally marked upon the casks in which they are sent out, and it is now common to stamp X, XX, or XXX, to designate such gravities as at the option of the proprietary may be determined upon, as a guide to the servants, and as a scale of charges. X was at first stamped by the Excise, or with their authority, on all casks and stores containing beer, which was deemed to be worth ten shillings *per* barrel, to denote that it was strong, and chargeable with duty accord-

ingly; but as this was determined by the consciences of the trader and his surveying officer, the latter of which was sure to predominate, the course gave rise to an infinity of disputes. Ten shillings afterwards became the duty *per* barrel on malt liquors not accounted small, and the letters X and T were introduced into the officers' books to represent EX*ciseable* and *table* beer respectively, till the total repeal of the beer duties in 1830 rendered all further notice unnecessary.

The general method of procedure in the fermenting department, is to finish the cooling of the worts by efficient refrigerators, and to pitch at 60°, or between that and 63°, in squares or rounds fitted up with attemperators. The attenuation is seldom carried below 11 or 12 lbs., and the heat is curbed within 70° or 75°, when it is started into pontoes containing from 10 to 20 barrels each, where it ejects its yeast into stillions. These smaller fermenting vessels are kept filled up by a self-acting apparatus provided for the purpose, consisting of parachute, tank, ball-cock, pipes, &c., by the agency of which a considerable burden of manual labour is avoided, considering the quantity of work required to be performed. The ultimate attenuation is from 5 to 7 lbs., and the stronger London beers seldom exceed 10 lbs. When fine, it is vatted in large quantities to improve its body.

VATTING PORTER.—The spontaneous and gradual decomposition which takes place in a large vat creates a peculiarly grateful kind of acerbity and fulness on the palate, which is not to be found in new or unvatted porter; it also creates an amalgamation of distinct flavours which have emanated from the temperatures and management of the gyles during fermentation, with that of the article which it may be advisable to blend

with it, to effect flavour and taste of age, be it of whatever description it may. This mode of preparation is properly denominated *mellowing*, a word significant of becoming *ripe*, and which lexicographers derive from *mel*, honey; and it is this mellowing and reduction of the bitter, from which the pre-eminence of large stores arises.

URE'S DELUSION.—False construction is more readily attainable than correct demonstration, and men's minds are more apt to censure without cause than to reflect and afterwards to decide wisely; and though Dr. Ure, in his Dictionary, under the article "Beer," has attacked the London brewers with more causticity than discretion, his credulity is less to be blamed than the fatuity of a class of practical brewers who in their writings have avowed themselves adulterators. Had the Doctor rested here, the subject might die and lie buried in his book without controversy; but in his "Supplement" to the Dictionary, recently published, he has renewed the assault with implacable antipathy, and the Mechanics' Magazine, for December, 1844, has given an echo to his accusatory declamations, which have been copied into several provincial organs of the press. The author, on perceiving the course thus taken, addressed a letter to the Magazine, which will be found in No. 1121, published February 1, 1845. It would be foreign to the nature of the present undertaking to travel over the whole field therein embraced, and still it might be accounted derelict, were we to abandon the defence which we have set up in order to clear the character of the brewer from charges so inexorably preferred. The Doctor has, in short, published a process for porter-brewing, which, were it known to the trade, would be utterly disreputable and ruinous; but which, as it stands, is fallacious, erroneous, and injurious to

the trade, in principle, practice, and detail. The following is a correct copy of the recipe, which, after a partial and meagre recantation, he imputes to the London brewers, except those which he calls "the most respectable establishments."

"*Components*:—

530 bushels, English measure, of good barley malt.
10 ditto of kiln-browned malt.
12 cwt. of *essentia bina*, *caramel*, or sugar fused over a fire into a dark brown or black syrupy mass.
1500 lbs. of hops, or about 3 lbs. to each bushel of malt.
10 quarts of *calfini*, a preparation made with the oil distilled from the outer bark of the birch.
5 quarts of good porter yeast.
Finings of isinglass dissolved in sour beer."

This he roundly boasts of as a discovery or "statement of the process for brewing *genuine* London porter," broadly "believing it to be more nearly that really practised than any formula hitherto published."

1. We will take five of the first London houses as an epitome, each of which on the average consumes 70,000 quarters of malt annually. Two-thirds of this consumption may be fairly estimated as the quantity used for porter, so that each of these firms must employ, according to his view, 422 tons 13 cwt. of *essentia bina* every year, all of which they must necessarily *smuggle* into each of their respective breweries!—And all escape? Cannot the Dr. find *one* vigilant exciseman or traitorous workman in so many, willing to receive an informer's hire?—Does he imagine that men of such capital as these brewers would be fools enough to subject themselves to the penalties inflicted by the statute of the 1st Geo. III. and several others above-named?—Nonsense!

He allows nearly 2 *per cent.* of "browned," not men-

tioning *black* malt; but the quantity consumed is about 4 *per cent.;* so that each of the breweries in question runs through 15,000 bushels, and all the London houses about 156,000 bushels annually, of an article of which a travelled author, who professes to give a prescription for *genuine* London porter, does not profess to know even the existence.

2. With respect to the introduction of the drug which he terms "*calfini*," the author has shewn this vituperative tirade of the Doctor's to many in the trade, all of whom, to a man, whether in town or country, declare themselves as ignorant as himself, of its name, quality, and substance. Moreover, the same difficulty exists as with the essentia, namely, that of being surreptitiously introduced to the *trifling* amount of 18,500 gallons a year: an exploit which magic alone could achieve.

3. "For 180 barrels of brown stout, containing from 80 to 85 parts of malt extract in 1000 by weight," he recommends "5 quarts of good porter yeast;" which is about $\frac{1}{24}$th of the quantity which absolute necessity requires to move the fermentation, and furnishes an indubitable proof that *Dr. Ure is not a brewer.*

4. With respect to hops. The quantity of malt consumed by the brewers of the united kingdom, averaging the last 5 years (*vid.* p. 104), was 3,780,086 quarters a year, and assuming as before, that one-third was spent in ale, the London brewers having used up 729,000 quarters a year, 486,000 quarters remain for porter brewing. Then, according to the Dr.'s arithmetic, the quantity of hops required to be used with the malt, at 24 lbs. *per* quarter, would be 11,664,000 lbs.; and as the average growth of these 5 years was 18,715,650 lbs. (*vid.* p. 275), no more than 7,051,650 lbs. remain to be used in brewing the 3,294,086 quarters of malt brewed into ale in London and in different ways throughout the

country, being 2 lbs. 2¼ oz. to the quarter, or 4 oz. to the bushel! Pursuing his correptious fulmination a little farther, we will assume that which is as near the truth as possible, namely, that 100,000 quarters of malt are now annually converted into bitter ale, and that the quantity of hops required for *this* purpose is *really* 2,400,000 lbs., he then leaves us 4,651,650 lbs. of hops on hand, to yield their flavour, and give preservation to the produce from 3,194,086 quarters of malt, *or less than a pound and a half to the quarter*, instead of 8 lbs., which is about the average quantity really used in brewing both ale and porter, excepting export beer. And this egregiously miscalculating dupe, thus drawn into unpardonable error, is who?—The actuary (*vid.* p. 274) of the "*British National Brewing Company*," whose concentrative powers are to swallow up the trade! Alas, poor Ure!

Seriously, the extensive convenience for storing, the large stock of all ages constantly kept on hand, the regularity of the system with which every thing is conducted, the tolerable perfection at which they have arrived in the various departments of the art, through their enlarged practice and skilful competition, are the principal causes of that superiority which distinguishes the porter of the London breweries from that of the provinces, where these essentials are not yet combined.

Porter is recommended by the medical world to their convalescent patients in poor families, in lieu of port wine, which antidote is exclusively appropriated to the wealthy. Here we may take the liberty of suggesting, that both classes of such invalids may advantageously now avail themselves of a yet simpler, more nutritious, and less alcoholic renovator than either, merely by a temperate imbibition of a moderately attenuated fresh *pale beer*, of about 20 or 24 lbs. gravity, or such as is

retailed at fourpence or sixpence *per* quart. This beer contains the essentials required by both doctor and patient, and which may be looked for in vain in either wine or porter; for besides containing water, gum, alcohol, and carbonic acid gas, in common with black beer, it possesses some glutinous matter and a fair proportion of nutrimental sugar; and its gum is rendered digestive by retaining its vigour and original elements; it is also better suited to weak stomachs and to medicinal and strengthening purposes than any black beer can be, since it contains less carbonaceous matter, and consequently more nutritious food, and is easier of digestion; whereas porter contains such a large share of this heavy mucilaginous matter, that it is better fitted to hardy and healthy constitutions, such as workers in metal, soil, or mortar, whose exercise enables them to carry it advantageously through the physical system; and, as regards port wine, little or perhaps none that reaches this country is free from adulteration with foreign alcohol, which is added to it either at the close of the fermentation, or immediately prior to its enshipment, and is never completely incorporated with the natural juice of the grape and its native spirit, notwithstanding all the art of "fretting in," of which the exporters are masters as adroit as they are fraudulent. However desirable the tartar of grape-juice is, as a component of wine, so little of it remains after bottling, that it cannot avail as medicine; whereas the tartar or gluten of malted barley answers the desired purpose, because it exists in sufficient quantity, and partakes of the same essential properties. The constitution of porter differs from that of pale beer by containing carbonised gum, little sugar or gluten, and is comparatively an indigestible beverage.

Of the effect which gum has upon the animal frame, we are furnished with a serious but interesting truth in

the admitted indigestibility of rice, and in an account given by Park in his Travels, of the emaciated condition of a certain uncivilised African tribe, who, during a scarcity of other food, live upon the gum which exudes from the stock of an indigenous tree, and which is of such difficult decomposition by the human organs, that it creates pains, and very often brings on endemic disease, which subsides only on their partaking of some animal or vegetable food which contains the azotic element, which is necessary to the exercise of the digestive functions. Here is little difficulty in seeing that symptoms of extreme debility must in many cases have occurred, attended, no doubt, with violent dyspepsia; and if gummy matter is so unfit for the support of the animal constitution, when the appetite is keenly on edge, how much more dangerous must it be to us at home, when administered to persons already sick and weak! Although starch gum is not imbibed from beer in very large quantities, yet its highly carbonised, and consequently inconvertible condition, makes it quite objectionable as food for invalids, whatever service it may afford to the healthy and strong; and notwithstanding that the gum which forms the fulness of porter, is admitted to yield more to the assimilative action in consequence of the accompanying bitter of the hop, &c., yet it is still obstinate during its digestion, even with some healthy people, as is also coffee, though aided in like manner by its own bitter principle and other matter conjoined with it. In both cases, the presence of the carbonised gum is indisputably the cause of the obduracy.

Ale differs from porter as much as tea from coffee, both in lightness and in stimulus; but neither of the high-dried kinds of beverage contains the nutriment incidental to the paler infusion, without the addition of some artificial matter; nor do they produce the same

cordial and exhilarating refreshment; yet where is the doctor who prescribes coffee in preference to tea, under circumstances of debility, depression, or indigestion? Strange as the truth may be, and observation assuredly establishes it in practice, gentlemen trained to the study of medicine pay too little attention to organic chemistry to bestow on this subject the serious consideration that it eminently deserves. In short, they prefer porter to ale, or, as they say, black beer to pale, because the former is generally in a sounder condition, and less disposed to acidity, and perhaps because it contains less *saccharine* matter; but to avoid both extremes, the whole of the pale materials may be brewed into a species of *dry ale*, like that prepared for the Indian market, though it is not less saccharific; and it is now notoriously remarkable, that though India ale was originally intended wholly to be sent abroad, yet, by the advice of the faculty, who have suddenly discovered its intrinsic excellence, it is now extensively prescribed as a medicine in cases of impaired appetite, weak digestion, and the like, which has given rise to its occasional and gradual introduction where means command access to good things, for the improvement and protection of health; and as this breaks the spell of custom, it is made to constitute the leading topic of a separate chapter.

CHAPTER XVIII.

EXPORTS.

ESSENTIAL QUALITIES OF STOUT—RECTIFICATION—AUSTRALIAN AND CANADIAN TASTE AND CLIMATE—EAST INDIA PALE ALE—QUANTITY AND QUALITY OF ITS HOPS—ORIGINAL AND CORRECT MODE OF FERMENTING IT—PROGRESS OF ATTENUATION—HOME CONSUMPTION—MEDICINAL VIRTUES—ULTIMATE STRENGTH AND BRIGHTNESS—SPECIMENS—CALCUTTA MARKET, AND MALT LIQUOR IMPORTS.

Since the materials and manipulation necessary for the production of porter in general, have been somewhat fully enlarged upon in the foregoing chapter, the writer will but briefly allude to a few principal points that more particularly bear upon the subject which now presents itself for re-inspection, viz. the chief features of porter or stout designed for exportation.

Of the various productions of the British brewery sent abroad to the many nations and climes with which our merchants hold intercourse, the principal are those exported to our Australian, Canadian, Indian, and West Indian settlements; and these, in consequence of the diversity of climate subsisting between those colonies and states, and not a little from the constitutional habits and taste of the several classes of consumers, are required to vary a little in composition. For the uniform mildness of Australia, and the changeable seasons of North America, a good fair article of porter, called stout, of about 28 lbs. *per* barrel, or something less than three barrels to the quarter, will suit, to obtain the

drawback of duty on materials. The grist from which such export beer is drawn, as well as the hops intended to flavour and preserve it, should be somewhat better than a good medium quality; and in order to excel, it is found necessary to use only one description of malt, except the colouring preparation, and that neither under nor over-dried, but of the purest *amber*. A winter's vatting seasons it for the voyage, and renders it fitter for exportation than if shipped immediately after it is brewed, however fine and spirituous it may be in its maiden state; but the stout intended for the East or West Indies should be more alcoholic from the commencement, and requires from 10 to 15 *per cent.* more bitter. About 14 lbs. may be sufficient for the Australian market, and 15 or 16 lbs. for the Canadian; but the Indian will require 20 lbs.

The custom of mixing a native thin-brewed beer of inferior quality, and not unfrequently a mere compound of water and molasses, with the imported stout, is a common fraud with some of the Australian and American dealers, who, by thus impairing the strength and flavour of the genuine import, and thereby increasing the quantity in their stock, enlarge their profits accordingly; by which misconduct they not only rob the consumer, but sometimes heap odium upon the innocent brewer, whose name and fame go hand in hand, the former being usually labelled upon the vessels containing his stock, and particularly if an honest and emulant man. He may, in some instances, have been ordered by the exporter to make the colour of his produce some shades darker than usual, as a false token of strength, by an additional allowance of patent malt, although it may conspire to shield the anticipated deception at the expense of his individual reputation. The consumption cannot be increased by this time-

serving and mercenary species of trickery; but an exposure and a good brisk competition may do much towards abolishing it, since the latter course has remedied an evil in the market of Calcutta.

The ultimate attenuation of the export stout should vary according to the climate it will have to encounter: that for India may have about 4 lbs. unattenuated; that for the milder and uniform climate of Australia, about 5 lbs.; and the supply intended for the more fluctuating, and often extremely hot or rigidly cold seasons of Canada, may have 6 lbs. unattenuated; and it is imperatively necessary that all extraneous vegetable matter, which forms the yeast, lees, &c., be removed, because the agitation during the voyage would otherwise provoke extreme fretting, leakage, and premature acidity. If the rumbling of a carriage in a gateway will acetify the beer stored in a cellar underneath, much more so will the rocking at sea, if due precaution have not been taken. Also, the nature of the materials employed, in order to supply a greater quantity of carbonic acid gas than can be generated by paler beer, demands an adequate number of vent-plugs, which should be made of a peculiar red oak, almost as porous as cane; and from four to six will not be too many, if the pores be partly choked up by yeast or other ejected matter. This plan is greatly superior to the iron vent nail, which indeed is now but rarely seen in any establishment professing to have embraced improved principles.

India Ale.—After the explanations and intelligence that have been given within the body of this work, on the subjects of boiling, mashing, fermenting, and the rest, nothing here, it is presumed, can be required in further elucidation of the practice of brewing, than that which is directly applicable to the best practical means

of obtaining the necessary properties and peculiar characteristics that distinguish a malt liquor made for exportation, and used as a medicine at home, from that which is manufactured for ordinary and general home consumption. In the foregoing chapter, allusion has been made to the introduction of pale beer by the faculty as a medicinal cordial. This practice has induced brewers to prepare an article that may be exclusively appropriated to domestic consumption, and yet retain the name of *East India Pale Ale*, because its treatment is the same through its several stages, the only difference being in the quantity of material engaged in its production, that for the home market being somewhat less bitter and spirituous, and in some cases a few pounds heavier than such as is exported to India. Thus the brewer has become a legalised vender of "doctor's stuff," and vies with the apothecary in "getting up" the prescriptions of physicians "according to order." The bitter of the hop appears to have all the properties of the coriander in its pungency and flavour, and also to possess, like some other exotics of the umbelliferous tribe, a stomachic and carminative power, without having the torminal attributes of senna and other drugs of pharmacopolists. According to a brewing writer who lived in the hop country, the spirit of that flower is "truly cordial and warm, exciting in the third degree, aperitive, abstersive, subastringent, digestive, discussive, diuretic, stomachic, and sudorific;" so that it has more real good qualities than have even been ascribed by Nicholas Culpeper, the prince of quacks, to his favourite wormwood: at all events, the hop acts as a tonic, antispasmodic, and cathartic medicine, and its aromatic bitter, when properly administered, restores the abused appetite. Hence the medicamentous properties of this beer of physicians may be in part attributed to the absence of

saccharine, mucilaginous, and general amylaceous superfluity, but principally to the highly tonic property derived from the quantity and quality of its hop, which corrects unwholesome nutriment, promotes digestion, and, in a singularly powerful manner, increases the nutritive virtue of all food united with it, and without undergoing any perceptible change while thus officiating in its passage through the animal system. It is particularly successful as a stimulating remedy for the deranged functions of the stomach, and acts upon the sympathetic organisation, so as to restore the debilitated system in general, and ultimately to give strength and vigour to the mental faculties and physical powers.

Like all other worts, those intended to form this unique medicine require speedy cooling, which will prevent too voluminous an absorption of oxygen; and hence the imperative necessity of an efficient refrigerator. They do not require more yeast than other worts of the same gravity, but it would be almost futile to attempt their fermentation without an attemperator; for it is absolutely necessary to conduct this process with the nicest regularity, since the ultimate purification and brightness will otherwise never be perfected. It is not needful again to allude to the peculiar kind of fermentation enforced by the subterranean expedient, farther than to observe, that nothing can equal its efficacy, and the uniform certainty which it will ensure in the manufacture of ales destined for a market such as that of India. The correctness of this remark, it is presumed, cannot for a moment be doubted; but the author will here confine the sphere of his operation to the provision of an ordinary brewhouse and common plant.

The malt should be of first-rate quality, perfectly dried, and very pale, colour being the first consideration

in point of importance; and the hops should therefore be of the palest growth; and in selecting those that impart the least colour, their maturity should not be overlooked. The quantity must vary inversely with the quality; but as the flavour of this kind of ale emanates more from the aroma and bitter of this flower than from any other material, from the ultimate extreme decay of the malt extract, it is advisable that the hops should be of the description which contains the greatest share of condition in the smallest bulk; reasons for which qualification have already been assigned (*vide* p. 247). Such as those designated *Goldings*, *Farnhams*, and the very best *East Kents*, may be used with advantage, and seldom less than 22 lbs. to the quarter will suffice.

In boiling liquids that contain vegetable matter, the colour of the liquor will not only heighten in proportion to the time of continuing the heat, but also according to the amount of solid present to be affected by the fire; in all cases, therefore, it would be profitable, as has been observed, to steep the hops in water of any temperature between 120° and 170°, for eight or ten hours, where such a heat can be conveniently preserved so long. In consequence of the extraordinary quantity of hops required for the ale, a rather considerable allowance must be made in the quantity of the raw wort, because of the great absorption in the hop-back; and although some little increase of density is gained from the hops, yet they retain possession of a degree of bitterness almost equal to that which they originally possessed. Hence, when the business of the day is over, they will be found to have sustained their strength with but partial exhaustion, of which condition advantage can be taken by reboiling them in the raw wort of the following day; and in this case, it will be better to brew porter next, as here the absence of the

aroma in the half-spent hops is not so deeply felt, and a smaller quantity of new ones, by 25 or 50 *per cent.*, will suffice, according as circumstances may demand. It may be well to caution the inexperienced brewer against the impropriety of leaving these partially spent hops in the hop-back over night, or even more than three hours, before their bitter is extracted or engaged for future appropriation; because during delay they undergo a partial decomposition, by which the efficacy of the bitter is diminished in proportion to the time that they are exposed to the air, when unable to maintain their acquired temperature; and the loss is still greater where the water contains carbonate of lime, the disengagement of which by boiling, and its deposition amongst the hops by filtration, accelerate the decaying process in the same manner as when applied artificially to manure and animal matter, to hasten putrefaction; a circumstance known and acted upon by agriculturists, and by the functionaries who inter the corpses of condemned malefactors within the London prisons. Where the hop-convertor is used, the exhaustion of the hops by one process is so perfect, that nothing remains in them to be of the least advantage by another operation.

The pitching temperature may be from about 56° to 60°, and the exciting yeast may be diluted with some of the wort, to which more may be added occasionally, as the worts are flowing into the square. The materials forming the extract, not being over-dried, or carbonised, on the kiln, or in the copper, will immediately evince symptoms of decomposition; and in order that the elements which aid the fermentation may be preserved as long as necessary, the heat of the gyle should occasionally be curbed by the attemperator, particularly soon after the commencement, and when the attenuation becomes rapid; with which resolution it should be con-

stantly watched, or inspected at least every 4 or 5 hours, by night and by day, during the first forty-eight hours, at the expiration of which period the heat ought not to be found to have increased more than 2° or 3°, and the saccharometer should indicate a diminution of 7 or 8 lbs. gravity. Should the attenuation and the heat not keep pace at this rate, as it probably may not if the water is of a quality to be termed hard, a little indulgence may be extended to the accumulation of a degree or two, or, which is preferable, the exercise of a little more patience may be introduced, and less frequent inspection will suffice as an equivalent for the extension of time. By the period when the attenuation has prograded to within one-half of the original density, the heat should not be allowed to rise above 62°. The remainder of the process will require very close attention; for as the attenuation approaches the crisis for its cleansing and purification from excrementitious matter, three-fourths of its saccharine being converted, the thermometer appearing rather below than above 64°, about one-half of the yeasty head may be skimmed off, and at the same time the tap of the attemperator may be turned off. When 2 lbs. more have disappeared, the skimming may be resumed, and about three-fourths of the head may be removed. The density will now be 6 lbs., and at least 2 lbs. more should be attenuated before the fermentation can be considered complete, and which, it is presumed, the previous skimming will not prevent. If any obstinacy is experienced on this account, a small quantity of its own yeast may be roused well in, and so much early skimming must be afterwards avoided. When, however, only 4 lbs. remain undecomposed, the gyle should be skimmed quite clean, and the cooling powers of the attemperator should be appealed to.

The stream and the heat of the gyle must continue to pass gently away, and the cleansing skimmer should be

put into requisition whenever the light head thickens to within an inch deep.

All that now remains to be done, is to expedite the clarification; and as we know that heat, or calorific repulsion, is a power opposed to aggregation, being as such repellent, a separater of particles, the attemperator should now be put in requisition to extract the caloric, and thereby encourage the natural affinity of each remaining azotised particle for the others, that through their gravitation, and combination, and ultimate quiescence, a speedy precipitation may take place, so that by remaining in this cool state a few days, it may be fit for the vat. To make this peculiar process the more perspicuous to the inexperienced, the author subjoins a few figures from the end of a brewing of his own, which may be taken as an example and tested as a guide. The square contains 200 barrels of wort, the *gravity* at pitching (commonly called *density*) was 24 lbs. *per* barrel, and the hop employed was East Kent.

Hours in Square.	Heat of Gyle.	Attemperator tap.	Attenuation.	REMARKS.
0	57°	off	0	With the aid of finings,
10	57½°	on		this ale became quite
22	58°	on	19·1	bright just 10 days
36	59½°	off	17·5	after racking.
48	60°	on	16·	Much admired by all.
55	60°	on	15·3	Self not pleased with
62	61°	on	14·	the hop. Try Farn-
72	61½°	on	13·	ham.
78	61°	on	12·2	
83	62°	off	11·2	
90	63°	on	10·	
96	64½°	on	8·5	
102	64½°	on	7·6	Partially skimmed.
113	65°	off	5·	Skimmed closer.
120	66°	off	4·3	Do. quite close.
134	60°	on	4·	Do. do. clean.
150	52°	on	3·9	Do. do. do.
160	50°	on	3·9	Do. do. do.
190	50°	on	3·8	Vatted one-half. Sent half out.

This precise time of fermentation is impracticable with such waters as are termed "hard," or such as the Burton brewers use. In these cases higher pitching heats and a higher fermentation are necessary for general practice, or where it is desirable to complete the attenuation without vatting, on account, as before observed, of the obstinacy with which worts ferment when so constituted; but with soft or medium water, the above Table may be followed with confidence and accuracy.

If found desirable, the attenuation may be carried a pound or two lower, as before suggested; and by proper management, the trial may be made with safety. To avoid premature acidity after its arrival at the place of its destination, it is necessary that all matter tending to its turbidity should be removed by attraction and precipitation, and that it should not be racked for exportation until it has become perfectly bright. About half a pound of new hops *per* barrel might now be added. The very small quantity of unattenuated matter yet remaining, should be no more than just sufficient to supply enough of carbonic acid gas for the requisite effervescence during its limited decay, without causing the slightest turbidity at any time, and to prevent its accumulating in excess, after shipping, and endangering the safety of the cask, a porous plug or two should be inserted into the shive or near it, through which the surplus gas may escape.

As regards the Indian market, it is presumed that the following information, given by a commercial firm of great respectability and experience in Calcutta, will be found as acceptable to the reader as it has been to the writer, as much from its novelty as from its undoubted correctness.

"Great Britain must always be the source whence British India is to be supplied with good wholesome malt liquor. Attempts have been made by the French,

Americans, and Germans, to supply it, but it has proved to be quite unsuited to the Indian palate: in fact, very bad. There is nothing to be dreaded from them; and although it is not impossible to brew good table beer in Upper India, yet it is not likely to succeed permanently, for various reasons. No person of capital would run the risk of losing it, as it is only whilst prices are high that he could be handsomely repaid; and in that case, the English brewer would be in the market, and upon equal terms at least. The cost of apparatus, materials, labour, and interest on capital, added to the expense of transportation from Muttral, or any other of the colder stations, to the principal towns of the central and lower provinces of Bengal, would be much greater than the English brewer's charges to accomplish the same object.

"Previous to the years 1816 and 1817, the demand for beer in India was nothing, compared with what it has become during the last seven or eight years. The pressing calls of 1821 for an increased supply, led Hodgson, of London, to enlarge his brewery, and induced some to enter into arrangements for monopolising the market: this, as usual in such cases, ended in severe losses to all concerned. Beer has for many years been an article of extensive consumption in Bengal, and it is highly probable that a greater increase would take place, were it not for the very high price to which it has frequently risen: this, however, could not be guarded against, as long as Hodgson exclusively had the supplying of the market; but now that other brewers can furnish equally good beer, there is no fear of a short supply, or of being subject to monopolies, such as were tried some few years ago. The great fluctuation in the price of this article has been caused entirely by the irregularity of the supply, and the plans laid down by Hodgson and some of his moneyed neighbours, to keep the

others out of the market. So entirely dependent were the public upon this brewer, that he in a great degree regulated the price and the quantity imported. Others who attempted to introduce their beer into the market were compelled to withdraw, having lost very considerably by their speculations; for Hodgson, when he knew that other brewers were shipping, sent out large quantities, and thereby reduced prices to such low rates as to frighten his rivals from making second shipments; and having effected this, the following years he had the market to himself, and the prices rose occasionally under the short supply to 180 Rs., and even 200 Rs., a hogshead. He thereby made up for the sacrifice of the previous year, and effectually deterred others from prosecuting their speculations in this market. Another thing in his favour, and which operated for a long time, was the high repute to which *his name* stood for beer; so much so, that no other, even of a good quality, was bought by the retailers, as they could not dispose of it. The commanders and officers were, up till 1824, Hodgson's best customers; his beer formed one of the principal articles in their investments, and it was customary for him to give them credit for twelve or eighteen months, if not for the whole amount of their purchase, at least for one-half of it; but about this time he not only raised his price from £20 to £24, but refused to sell on any terms except for cash, even to parties of unexceptionable credit. This naturally drove many of his best customers to other brewers, but Hodgson and Co., confident of the power they had in the market, sent the beer out for sale on their own account; and thus they in a short time became Brewers, Shippers or Merchants, and even Retailers. These proceedings naturally and justly excited hostile feelings in those engaged in the India trade at home, whilst the public here, seeing the complete control which Hodgson endeavoured to maintain

over the market, turned their faces against him, and gave encouragement to other brewers, who fortunately sent out excellent beer.

"In 1825 and 26, several brewers tried the market, and as the spell had been broken, met with liberal and fair encouragement. The most successful of them were Alsop and Son, Bass and Ratcliff, Ind and Smith, and Charrington, with a few others. It being therefore clear that England must furnish the supply, and it being the interest of the brewers to keep the market steadily supplied, we shall now give some data to guide the brewer or shipper.

"It will be perceived that since 1830-31, (the 30th of April terminating the Indian Commercial Year,) the imports of Beer and Porter into Calcutta have increased nearly 100 *per cent.*: this in a great measure arises from the moderate rate and little fluctuation there has been in prices, whereby a taste for beer has been more generally diffused throughout the poorer classes of British inhabitants, which having once acquired, they will continue to indulge as long as prices continue moderate.

"*Imports of Beer and Porter into Calcutta.*

Year ending April 30.	Butts.	Hogsheads.	Dozens.
1830–1......	418	5,566	2,105
1831–2......	111	5,946	1,167
1832–3......	252	7,916	2,293
1833–4......	322	7,193	2,028
1834–5......	244	6.282	2,632
1835–6......	140	4,519	1,392
1836–7......	404	9,544	3,241
1837–8......	841	11,356	2,102
1838–9......	606	8,937	719
1839–40	391	10,779	671
1840–41	824	11,808	2,989
1841–42	669	11,035	6,457
Total in 12 years....	5,222	100,871	27,796

"The beers now most saleable, and which command the highest quotations, are those of Messrs. Alsop and Son, Bass and Co., and Ind and Smith, especially the former, on account of the superior lightness and brilliancy of their shipments: there is, however, a wide field for competition, and we have little doubt that by caution and care, one of the most lucrative and extensive businesses might be opened with the port. The first point for consideration is, quality, a few remarks on which may not, we trust, prove uninteresting. The ale adapted for this market should be a *clear*, *light*, *bitter*, *pale* ale, of a moderate strength, and by no means what is termed in Calcutta 'heady;' it should be shipped in hogsheads, which we need scarcely observe should be most carefully coopered, and small shipments and frequent, in preference to consigning heavily at one time, as the natives, who frequently purchase on the invoice, (which by the by should always be made out at an advance of prime cost of 50°/$_{o}$, as invoices are sold taking the rupee at 2*s.* 6*d.*, and generally at a discount of from 5 to 10°/$_{o}$) cannot often raise funds to take off the same. Another point is, that by frequent consignments you acquire a *name*, which, as you may be aware, is every thing in India."

This highly interesting, instructive, and masterly commercial letter, says so much on the subject of *British Medicinal Ale*, that the author of this work would be deficient in common politeness, were he to offer any other commentary upon it, than to tender his best thanks to the intelligent writer of it, and with this simple observation he is contented to leave the subject in the hands of his readers, while he attends to some other matters.

CHAPTER XIX.

STORING.

OLD AND VATTED BEER—SPONTANEOUS PRODUCTION OF ETHEREAL STRENGTH —THREE SYSTEMS—AMALGAMATION BY REPLENISHMENT—REGENERATION —REMEDIES FOR ROPINESS—THE OILY SHIELD—EVAPORATION IN STORES —CELLARS AND RESERVOIRS CONSIDERED—SIGNS OF FITNESS—WASHING CASKS—PAYNE'S PRESERVATIVE PATENT—STEAMING CASKS—DAVISON AND SYMINGTON'S CLEANING APPARATUS.

THE public taste having in many places now greatly changed from new beers to old, and a more general revolution being quite apparent, it must give a stimulus to the consideration of the subject, and the most desirable means to be adopted for the uniform production of a pale, bright, aged, and sound article.

Without entertaining any of the expedients to which recourse is had by a few of the victuallers in Birmingham and elsewhere, and probably in some breweries also, to give to fresh ale the flavour of old, the author would recommend the employment of as much additional capital as will enable the proprietors to store largely, and to ferment accordingly, which will well repay them in the end. He has often observed, with a degree of astonishment, the great difference in the quantity of carbonic acid gas which escapes from ales that have been fermented very low, and from those wrought at high heats, original and final gravity agreeing. The intoxicating effects of the former have perhaps been exaggerated by some writers, though such

highly gaseous drinks certainly are fuller on the palate, more refreshing in the quenching or assuagement of thirst, and more exhilarating in their stimulus, and of course more alcoholic or ethereal.

Where the trade is extensive, and vat-room is of consequent importance, large stocks of old ale and porter being required to supply the consumptional demand, *underground tanks*, made of brickwork, to contain from 500 to 5000 barrels each, will be found convenient, and if lined with felspathic tiles, will be considerably cheaper than wooden vats of like capacity. The expense of brickwork, whether 18 or 24 inches thick, is easily estimated, and requires no calculation here. The tanks, for ordinary purposes, should be about the depth of cellars constructed for the usual storage of barrels; and, in the absence of felspathic tiles, Wyatt and Parker's cement would be found more serviceable as a lining, or to bind a lining, than that in common use, which is a perishable composition.

In treating on the subject of old beer, the author may perhaps be pardoned, should he name certain localities which have attained celebrity from their mode of storing and preserving it. The ales sent from Wiltshire, and some parts of Hampshire, to London, are generally old vatted stuff; and the observant brewer can scarcely pass through a street in the metropolis without beholding some such inscription as one of these decorating some public-house front or end wall,—"Sparkling Wiltshire Ale," "Splendid Alton Ale." Marlborough and Devizes are noticed by travellers for the excellent quality of their pale-coloured sixpenny "beer," fourpenny "ale," and twopenny "slap;" but other towns furnish superior breweries. Berkshire also sends her cargoes up to town, and the greater part of these are not new, but manufactured and stored with peculiar

care, and are truly excellent, as are likewise some of those from Nottingham, equal in repute with Burton XXX; and to the getting-up of a commodity like these, the author is convinced that the system which he has herein propounded is most particularly and appropriately adapted. To do this in perfection, adequate means, as already hinted, and as in other undertakings, are indispensable; amongst which means may be included talent and experience; for it is not the province of novices, in any trade, to give the master-stroke to a prime article. The materials should be of the palest and best description, and the colour of the extract is best preserved by gentle steam-boiling. All malt liquors that are intended to partake of the character induced by long keeping, require extra hop, both in quantity and quality, and should be attenuated as freely, and at such heats, as the circumstances of their ultimate disposal, their connexion with other beers, the temperature of the stores, the duration of the storage, and other considerations, may demand, and for which no positive instructions can be laid down beyond the test proof of skill and experience.

The amelioration of vinous liquors by age, or the changes which their constituents undergo before the full developement of their most agreeable qualities, does not appear to be understood: indeed, it is a subject so darkly wrapped in obscurity, as to render a present satisfactory result of the enquiry next to impossible. Under some circumstances we may suppose that the aqueous portion escapes by absorption and evaporation, though in other instances the spirituous parts appear to be thus lost, notwithstanding that the vinosity and mellowness are at the same time improved. One extraordinary fact may, however, be demonstrated, which is, that time deprives all vinous liquors of a great propor-

tion of their alcohol, while it wonderfully increases their exhilarating powers. The attribution of this singular acquisition of potency, to the diminution of the alcohol and the formation of a cereal or *demeteric* ether, by some peculiar and newly acquired state of combination of the former alcoholic elements, or rather of their return to a retrogressive union, has been undertaken in Chapter XIV. of this work (p. 425); and experience, aided by reflection, strongly tends to substantiate the idea. A gradual dissolution of the constituent principles of vatted beer appears to be continuous and universal; and although the elements for a considerable time virtually increase the alcohol, they are either acting under a new kind of arrangement, or they afterwards, through the agency of time, contact, decay, or other inexplicable cause, assume an ethereal character, in some measure identical with that former spirituous state which had its origin in the gyle-tun.

In preparing old beer, the fermentation and general management may be variously conducted; but three distinct systems shall here be particularised. The density, of course, depends upon the price that it must reach, and on the original cost, but is seldom under 30, or above 40 lbs. *per* barrel. By the first of these systems the worts may be pitched at about 55°, where the temperature is not constant, if the various circumstances elsewhere noticed will permit; and it must be well blended with just sufficient yeast, at the option of the experienced operator; for the process of fermentation has been sufficiently dilated upon to preclude the necessity of repetition here. Let it then suffice to say, that all surplus caloric generated during the fermentation above 68° to 72° should be extracted, and that the attenuation should be continued till it is as low as is consistent with the security of the gyle, which may be from

4 to 6 lbs. *per* barrel; for the lower any beer is attenuated, the more easily it will incorporate with other beer. Where that almost indispensable contrivance, the attemperator, is still wanting, a judicious seizure of the cleansing point must be observed, to avoid the dangers and evils attendant on a low attenuation without this instrument. Beer brewed and vatted entire in the month of March will probably be in a fit condition for consumption in the following spring; but if brewed in November, it will require two winters to ameliorate and become all that is desired; but then it may be approved more than March beer. To prevent too rapid a decline during the summer months, it would be advisable, towards the end of March, to fine and rack that which has been brewed at the commencement of winter into another vat, adding to it some new hops. When such beer is in a fit condition to rack, the lid ought to be removed from the manhole; and a few gallons of good finings, dispersed evenly over the surface, will expedite its brightness, if not quite perfect it, and tend to ensure the permanency of its good qualities.

The second system may be continued like the first, through its whole process, as far as vatting, when in lieu of storing it by itself, the following plan may be adopted. Rack from a vat that is in a desirable condition for consumption, one-sixth of its contents, and fill it nearly close to the manhole with the new gyle, which we will suppose just sufficient to fill the vacancy. Let the process of racking and refilling immediately follow each other, and let this drawing be repeated once every two, three, or six months, according to the period enforced by the temperature of the stores and other circumstances that affect the amalgamation, and control the arrival of the beer at maturity. These replenishments should be inserted through the lower and

middle taps, that they may ensure a perfect incorporation with the old beer remaining in the vat; because the assimilation will thereby be greatly accelerated; whereas, if merely poured through the manhole upon the top, the proper blending could not be accomplished without incurring considerable trouble and some danger. Where this practice can be carried out to advantage, the quality of the beer may be kept uniform, and maintain its peculiar character, the aroma of the new materials agreeably commingling with the ameliorated state and ethereal strength of the more aged for an unlimited period. Such is the power of contagion, that a good stock of old beers may thus be kept on hand for a constancy, and at a most economical rate, storage-room, time, and capital considered.

The third is a spontaneous process, a description of which, to those who never tried it, or speculated on the theory of their profession, may probably appear doubtful, and perhaps a little extravagant, if not impracticable. It consists in merely vatting the worts directly from the coolers, trusting to their native ferment, and that left by the former gyle, for their gradual decomposition. The worts are seldom pitched by themselves, and rarely into a recently cleansed vat; but a safer and more economical method would be to draw as much from a matured vat at once as would be immediately replaced by the new worts. One thing must be observed, namely, to take care not to add the worts to any beer containing a superfluity of acetic acid; and it is also essential that the temperature of the vaults containing the vats or stores be not subject to great variations, otherwise ropiness and other evils will be created by the process; and though it necessarily occupies considerably more time than usual, the yeast gradually forms when in a mild and stable temperature, and

accompanies the old grounds, giving to the beer superior properties, which undoubtedly distinguish it from all other sorts. But where, be it asked, is the brewer, especially in London, who possesses storage, cellarage, or vault-room, at all adequate to the object of thus improving his liquors? Here, again, the author cannot refrain from adverting to that greater security in which that man may work, who either possesses a naturally formed store, like that of Mons. Chapnis, as described in Chapter XII. (p. 375,) or who has incurred the expense of excavation in providing one; for, with such a place to ferment and store in, his beers may be made to surpass every other beverage, and accordingly to merit and obtain universal approbation, and as Johnson remarked, to realise "the potentiality of growing rich beyond the dream of avarice."

Having above mentioned ropiness, it may now be well to point out both its cause and its cure. This malady is never evinced in beers that are sufficiently attenuated and free from glutinous compounds and improper acid mixtures. Whenever the quantity of mucilage is large, it is accompanied by a superfluity of undecomposed gluten also; and these constitute the body and fulness of malt liquor; and their mutual affinity for oxygen is so great, that an extraordinary absorption of that gas takes place, bearing proportion to the quantity presented, by acids or otherwise; its absorption is also facilitated by the heat which the process developes, or is imparted to it by the atmosphere. In this case the glutinous and mucilaginous properties appear to have united, and they partake of new constitution, form, and appearance, in consequence of possessing this influx of oxygen, and the consequent abstraction of a portion of the carbon: hence the viscid and oily effect termed "the rope," which may be remedied by either of the following means.

Add about one-fourth of new wort, of such a heat as will raise the temperature of the whole to about 70°, and put to the mixture one pound of fresh yeast, and one ounce of cream of tartar, *per* barrel; rouse well together, and keep tolerably close: this will not only cause a fermentation of the new wort, but a decomposition and recomposition of the rope, by abstracting the superfluous oxygen, and imparting the necessary carbon. The second medicament is this:—To every 100 barrels of the diseased beer, rouse in from 25 to 40 lbs. of ground mustard-seed, previously liquefied, and a few days afterwards steep half a cwt. of good hops in hot liquor, and strew them over the surface; in the course of a week more a few gallons of finings will render it sufficiently pure to be mixed with a better article at racking for sale and early consumption. This latter plan is, for many reasons, particularly where much acidity exists, the more advisable.

The contents of a vat are always stalest in the upper part; a proof that the decay of beer is the most rapid where least compressed and most exposed. A flask or two of olive oil, poured on the surface of vatted beer about the beginning of April, will effectually exclude the oxygen on that quarter, and be of more real service than could be expected from a shield so cheap and simple.

The subject of waste incurred by the use of wooden vats of different sizes, seems hitherto to have been overlooked by the trade. The loss arising by evaporation and absorption is nevertheless very considerable, and increases in proportion to the length of time occupied in the storage; and the smaller the vat the more wasteful it is, because the area of its several surfaces is greater in proportion to its capacity than in one of larger dimensions. In ordinary store-rooms, for ex-

ample, and particularly in those where the vats are perched up as near to the sun as possible, notwithstanding the expedient of double roofs to such places; a vat of 100 barrels will lose by evaporation from 2 to 4 *per cent. per annum*, while one of 1000 barrels will not shew a deficiency exceeding 1 *per cent.* from the same cause; but still this is sufficient to prove the inexpediency of storing in vats of so porous a character as wood. Much of this loss might be prevented by furnishing each vat with a small valve, opening outwardly, and loaded with a pressure of about 1 lb. *per* square inch, whereby the expansion of the gases would find relief, instead of forcing the liquids through the pores and joints, or endangering the safety of the vessel and its contents. The best cellars are slightly humid, and ought to be dug as deep as local circumstances will permit. Dry cellars will evaporate from 50 to 75 *per cent.* more of the spirituous contents of their stores than those that are damp. Where it is desirable to keep a large stock constantly on hand, the common wooden vat should, for reasons already assigned, make room for a cheaper and more durable storage; such as tanks or reservoirs of brick or stone, lined as aforesaid.

Washing Casks.—Previously to racking, it is of the first importance to be assured of the sweet condition and sound state of the casks; for should any be otherwise, it will injure the beer, and perhaps make it undrinkable. Some casks, through lying in warm and open places, shrink and ultimately leak; while others, though less neglected, have grounds, hops, and such vegetable matters, investing their pores and channels, till in the last stage of putridity, which engender noxious gases, and create mould and other ruinous consequences to the wood, and every thing in contact with it.

Casks that are not kept long on ullage, and that are

speedily refilled, need no other cleaning than rinsing with boiling liquor; but those that become mouldy and otherwise foul, whether through age, situation, neglect, or other causes, avoidable or unavoidable, stand in need of some more searching power, as by mechanical friction, or by chemical re-agents, such as chloride of lime, long black pepper, charcoal, sulphuric acid, or some such *nostra*, as have been adverted to in the preceding chapter. Every writer who has touched upon this apparently simple subject, after cautioning the young brewer against the use of unclean casks, has imperatively enjoined the necessity of their *dryness*, and has extended the same advice with respect to vats, &c. Certain as it is that large quantities of well-brewed and excellent beer are spoiled by being put into foul casks, yet it is extremely questionable whether a dry barrel is preferable to a moist one, and for these reasons:—Experienced men well know that only a few years back all brewing utensils were washed with hot liquor, and that the coolers, especially, were swept off by a whole posse of men, as speedily as possible, to admit of their being mopped perfectly dry while hot. How different is the practice now! Everywhere, in the metropolis at least, is cold water substituted for hot, except where some obstinate and peculiar kind of contamination requires a deviation from the course; and the coolers in particular are purposely kept wet till the worts are admitted to cover them; and the obvious reason of this change is, that the pores of the wood may be occupied by water rather than by atmospheric air.

The effects produced by worts on porous coolers and their displayed aërial contents, have already been adverted to in Chapter X. (p. 313—18,) and the same observations apply to porous casks for beer, though the remedy is not always so readily available. If beer that

is put into wet casks does not ripen and sparkle so soon as the contents of dry ones, the difference may more correctly be attributed to the absence of air than to the presence of water; for ales impregnated with atmospheric air decompose with facility, and, as we have shewn, or as is well known to experienced persons, next to heat, as an incentive to every species of decay, is oxygen, so that the brewer ought to avoid it as much as possible: hence, then, no harm can arise from filling a *sweet* moist barrel, but some injury may be inflicted by a sweet dry one.

In all properly regulated establishments a system is pursued, and a part of it is, that the duty and responsibility of examining the casks, and turning into the store-room no others than are clean and sound, devolves on a cooper or other competent person, whose duty it is also, in many cases, to tap and plug them for use, and to return to the wash-house or cooperage all that he finds in an unfit condition. Where steam is not to be had, stinking casks need unheading and scrubbing out with hot liquor; and if they are scaled, or harbour the mould or other filth, the foul part requires paring off; and they often undergo scraping, and even firing; but as a cure is not always effected by such means, though ever so skilfully applied, or as it is attended with great expense and delay,—when the head has been replaced, a few gallons of sweet grounds, with a little sulphuric acid, and a few ounces of chloride of lime, may be put in, and the cask, being immediately filled nearly full with boiling liquor, and bunged down close, must be rolled over two or three times, when the internal commotion caused by the decomposition of those contents of the cask, added to the internal pressure from the expansion of the liberated gases, will completely neutralise and dissipate all putrescence; for the searching

powers of this remedy reach a considerable distance into the pores of the wood. A moderate "stinker" may be rendered perfectly sweet by being kept in this condition a few days, if occasionally turned over, and then put to stand on its end, so as to subject every stave and piece to the influence of the correctives.

Admirable as the construction of a barrel is, to afford strength, durability, and ease of locomotion, it is still capable of very considerable improvement, either in the material of which it is made, or by the adoption of such means as render the wood harder and less porous. The German brewers, who have the repute of being far our superiors, have doubtlessly seen the inconvenience arising from the casks absorbing the beer, and inflicting injury by admitting the atmospheric air through their pores, both casks and contents suffering upon the decomposition of the imbibed fluids, and the consequent acidity of the wood. Hence their precaution of lining their casks with pitch. No such protection is taken by other brewers; but notwithstanding that such or any similar "new-fangled notion" may be jeered at by the anti-innovators of the British brewery, the subject assuredly deserves a little thought; and the author suggests that brewers' casks may be rendered more durable, and their pores may be effectually stopped, by subjecting all casks, whether old or new, to Payne's patent process for preserving timber; and for this purpose he subjoins an abstract of that gentleman's specification.

PAYNE'S PATENT FOR PRESERVING TIMBER, granted July, 1841, to Charles Payne, of South Lambeth, Surrey, chemist, for "improvements in preserving vegetable matters, when metallic and earthy solutions are employed."

The wood to be preserved is placed within a strong vessel, and the air is then exhausted by air-pumps

both from the vessel and from the interstices of the wood; after which the vessel is filled with the metallic or earthy solution proposed to be employed, and after standing a short time, the solution is forced into the pores of the wood by force-pumps or columnar pressure; and when the wood becomes sufficiently impregnated, this solution is drawn off, and the vessel is refilled with a second solution, suitable for decomposing the matter of that which was previously employed, by double or single decomposition, according to the result desired. He does not confine himself to any particular solutions, but gives illustrations of his mode thus:—Firstly, he impregnates with a strong solution of sulphate of iron (*vide* p. 487), which he forces into the pores, either hot or cold, by exhaustion and pressure, from a solution of any of the carbonate alkalies, or of any other substance which will decompose the salt, and render the oxide of iron insoluble; and, secondly, he impregnates the wood with a strong solution of alum (*vide* p. 487), which he decomposes by a solution of carbonate of soda, of a strength suitable to effect that purpose. In order to obtain the matters of the first solution in a more concentrated form within the substance of the wood, he sometimes dries the wood, or partly dries it, between the two processes; by which device he likewise disposes of some of the aqueous matter, thereby facilitating the latter process of impregnation and decomposition.

The patentee recommends the application of his process generally to "ship and house building, public works, piers, sleepers for railroads, engineers', *coopers'*, and millwrights' work, wood pavements, cabinet work, hop poles, and *wherever* wood is used;" extending it also to canvass and cordage, such as "sails and rigging of ships, canvass for tents, tarpaulings, and for an infi-

nite variety of purposes," which "are by this means effectively protected and improved" against fire, wet, and dry-rot, and the ravages of insects, through "a complete change effected therein, capable of resisting external influences, and effectually stopping internal decay." Moreover, "the most porous, the softest, and of course the cheapest woods, are rendered equal in point of usefulness, durability, and *strength*, to the hardest and best of timber:" it is also "susceptible of the finest polish, and by the use of given solutions, can be dyed throughout with many of the most approved colours."

If all this is true, (and we must take that as a postulate till we can disprove it,) it must be an admirable acquisition to exporters; and for that reason the author, at the time of publication, is commencing a series of experiments with casks thus prepared; being induced to do so from the idea of the iron and alkali undergoing such decomposition within the pores of the staves and ends as to become insoluble; for should this asserted insolubility be proved, the benefits arising from the permanence of the material must be immense, because of its inability to impart any injury to the beer. In speaking of the imbibition of liquors by casks, he can add, that this property is much greater and more injurious in its results than is generally attributed to it: for instance, he has assisted in extracting as much as six quarts, and even two gallons, of fine rum from an empty puncheon, and a full quart of acetic acid from a void beer barrel! We cannot expect to find out at once an universal antidote for all the mishaps and losses to which the trade is liable; but if these observations should lead to beneficial results, it is *one* step gained towards perfection, and should encourage us onward to the discovery of something else that might be of avail,

and mayhap lead us to stumble upon some hidden truth of greater magnitude. The proprietors, Messrs. Payne and Loder, of Whitehall Wharf, admit that "the machinery, from its strength and great care and nicety in putting it together, is necessarily very expensive;" but as it appears to have been adopted by the Board of Ordnance, and by the Commissioners of Woods and Forests, it bids fair to turn out a very valuable speculation, especially as a piece of deal thus prepared was carried out to India in June, 1841, and put upon the floor of an out-office, where it remained unmolested in May, 1843, though the white ants had "established a large colony beneath the under-surface of it," and had attacked an unprepared piece within six inches of it, on the second day after its posit, till "on the eighth day scarcely a vestige of it remained."

Steaming Casks.—Instead of washing casks in the common way, many brewers now avail themselves of the advantages of steam in the wash-house, by means of an apparatus arranged and applied in the following manner:—Across the middle of a long trough, made like a stillion, a square hollow flat bar is fastened, on the middle of the upper side of which a perfect brass cone is fixed; a steam pipe enters one end of the hollow bar, and a liquor pipe the other; and by turning on the steam and liquor taps, the contents of both meet at the base of the cone, and make their exit through its perforations, either together or separately. When a cask in ordinary condition is to be "blown off," the workman having withdrawn its tap and drained it, he places it with the bung-hole downwards, over the cone, and turns on the steam-tap, and in the course of a few seconds turns on the hot liquor tap also. The steam now keeps the liquor in a boiling state, and disperses it with considerable force round the interior of the cask,

until it is about a quarter full, when it is rolled off the cone, washed on the outside, emptied, and stacked to drain. This method, though an expeditious way of cleaning an ordinary cask, will not cure a foul one; but a remedy has been found.

It is well known (*vide* p. 484) that new oak contains a large quantity of gallic acid and tannin, and it is the disengagement of these principles from the staves and ends of new casks, that imparts hardness, roughness, and badness of flavour and colour to such pale beers as are sometimes imprudently placed within them; and hence some few coopers are accustomed to subject their new casks to a kind of seasoning before they deliver them to the brewer; after which the latter often considers it necessary to fill them two or three times with inferior beer or other cheap commodity before he ventures to entrust them with his best ales; but all this troublesome precaution, expense, and risk, may be avoided, and the injurious acids and tannin may be removed in a most effectual and surprising manner, by a judicious application of the searching and volatilising virtue of steam! Such is the elasticity of inventive genius!

Some brewers of the old school object to the principle of steaming casks in any way, on the ground that the timber is injured thereby, and rendered less durable; but the present author for himself deposes, that having paid some little attention to this department of his business, in common with others, and having steamed and washed both his old and his new casks *for many years*, he hopes to be pardoned for dissenting from that ancient doctrine. He has also found that the healthiness and durability of a cask depend very much upon the kind of water used in the operation of brewing, and that the interior of all casks is much more protected

from acidulous and vegetable formations when water containing either the carbonate or the sulphate of lime is used, than such as is deficient of these properties; because the incrustation formed by the deposition of such calcareous matter protects both the wood and its contents by self-insinuation, whereby it renders the pores antiseptic; and casks that have had their interior charred to blackness possess the same qualities. In either case, the most perishable constituent of the timber, which is its albumen, is either rendered imperishable, or is totally destroyed. It is only necessary that organic bodies should commence decaying in the smallest imaginable degree, and be a little moist and warm, to cause the seeds of the all-pervading *cryptogami*, such as the *fungi*, *musci*, &c., commonly known as mildew, mould, moss, toad-stools, dry-rot, and a long tribe of other names, to develope and reproduce themselves by a singular species of vegetation; and the rapidity of their growth is strikingly exemplified in the interior surface of a washed barrel, sometimes even within a few hours after leaving the wash-house. Casks which have been steamed by a proper chemical process are exempt from these vegetable propagations, because the superior dry heat of the steam has not only destroyed and dispelled the germs that previously existed, but the cask having been made hotter, all superfluous moisture has evaporated and left it perfectly dry, and without a basis of food for the renewal of vegetation.

Now a mould, fungus, or whatever it be called, notwithstanding its insignificant appearance, acts the part of a ferment on vinous liquor; and as moisture is its chief propagator and harbinger, the necessity of immediately filling a barrel after it has been washed, must be as evident as the superiority of steaming; and the author, in furtherance of this subject, makes bold to assert,

from direct experiment, that such casks as are sufficiently and properly steamed, as above mentioned, are far more durable than those that are merely washed or rinsed; and he knows no scheme so applicable and efficient for the purpose of either brewer or distiller, unless it be the following, which is strongly recommended in the Mechanics' Magazine of May 25, 1844, as, "comparatively speaking, cheap, and in respect of efficiency subject to no drawbacks," but "a very common-sense-like improvement, and one which, now it has been thought of, every one will (as usual) wonder was not thought of before. This device consists in the substitution of *hot air* for steam; so that in administering heat, in which alone the editor avers that the purifying virtue consists, "free from the moisture which accompanies it in the state of steam," and which he says, though erroneously, "is found to do more harm than good;" because, of course, when not properly managed, "the wood imbibes from the steam a quantity of moisture, which helps to reproduce those very fungous impurities which it is the special purpose of the process to get rid of." This new contrivance is the production of two London Civil Engineers, and is entitled,

Davison and Symington's Patent Method of cleansing, purifying, and sweetening Casks, Vats, and other Vessels: patent issued in November, 1843. In the use of this apparatus, the patentees have the twofold object of, 1, freeing the wood of casks and other vessels, while being manufactured, from any injurious colouring or flavouring matter contained within the pores; and, 2, purifying them when finished and in use, from mould, must, fungi, or other like matters collected on their inner surfaces, by means of a machine which may be applied inside them without removing their heads,

" partly by *rinsing*, and partly by causing currents of hot air to pass rapidly through them."

First. The casks or other vessels are manufactured in their green state, which allows them to be afterwards bent without blistering; they then block them off with temporary fastenings, making due allowance for after-shrinkage, and subject them to the rapid current of hot air, which constitutes, as they profess, the merit of their patent, till all the natural sap, or as nearly as can be, is exhaled, after which they hoop and finish them for use in the customary manner. This hot-air apparatus consists of a furnace, with a number of horizontal pipes extending along its side, from which pipes issue others of a crescent form, communicating vertically. The atmospheric air is propelled through them by means of a fan; and a number of "nozzles" are fixed upon the main outlet pipe, on which the casks are placed to receive the current of heated air.

Second. For the purification of casks which have been in former use; these they place upon a frame, having four or more upright standard supports within which it revolves when in operation, having bearings and a rigger which communicates motion to this inner frame, from a driving pulley fixed on a horizontal shaft, over which a chain passes. The cask to be cleansed being put upon the frame or "cradle," is furnished with springs or "palls," and secured by a lever and chain, which lever is held by a kind of catch. An inclined plane is also attached, and causes the lever to act upon ratchets, and a clutch handle throws the whole apparatus in or out of gear, as opportunity may require. A plug in the shape of a conical frustum fits the bunghole, of whatever size it may be, and has a few inches of common chain containing a swivel, suspended from a staple

or eye inserted in the plug and made secure. At the lower extremity of this chain is a ring, from which they again suspend three or more other chains of a peculiar construction, each about three feet long; and to each of these lengths of chain, by means of a ring as before, are attached three more pieces of a smaller kind, and about a foot in length. Then when the machine is put into action, through the horizontal shaft or driving pulley, the rigger, as before stated, causes the frame and its cradle to revolve; and as soon as the ratchet and lever affixed to the spindle of the cradle reach the bottom of the machine, the lever comes in contact with the inclined plane, causing it to act upon the ratchet, thereby moving the cradle in a sidewards direction, to the extent of a tooth of the ratchet; and for every revolution made by the outer frame, the cradle again moves on in the same direction, and to the like extent, the chains, by means of their numerous angular points, that while removing whatever substance may have adhered to the interior surface of the cask.

This process, and a subsequent rinsing with a little of the beer with which it is intended to fill the cask, they deem usually sufficient; and any number may be put in revolution at the same time, recourse being had to a little alteration in the mechanical means, which may be done by any person possessing a knowledge of driving pulleys; but in the case of spirit casks, or such as have become extremely foul, they employ the hot-air apparatus, as in the case of new ones, first removing the corks, &c., to give free passage to any aqueous or other vapours generated by the action of the hot-air; and they add, that where an exceedingly high temperature is requisite to remove an excessive impregnation with noxious matter, such as must or char, " it may," after all, " be found useful to introduce along with, or in

addition to, the hot-air, *a small quantity of steam;* and for this purpose a boiler is placed over the heating pipes, having a pipe furnished with a sluice cock, through which the requisite supply of steam may be conveyed in the hot-air exit pipe.

Where casks in large numbers are daily under the operations of rinsing, steaming, and scrubbing, it would certainly save considerable manual labour to apply this new apparatus, and the ordinary number would be cleaned in less time and more efficiently, besides the perfect manner in which they would be dried, and the evaporation of any effluvia that might lie lurking in the pores. This alone should induce its adoption in every brewery, large or small. It appears now so far preferable to Ortman's machinery, noticed in the former edition, that the author cannot do less than express his cordial approval of the plan, and to repeat, that should further information be required concerning this or any other invention connected with his profession, he will at all times be happy, if within his power, to furnish it in the most candid and explicit manner within the scope of his understanding.

CHAPTER XX.

RACKING.

HOPPING—OPPOSITE PRACTICES SCRUTINISED—NETS AND BAGS—CLARIFICATION—THE FLOATING RACKER—ISINGLASS; SORTS, SOLUTION, AND OPERATION—MISAPPLICATION OF FININGS—WYNN'S CLOSE RECEIVER—USE AND ABUSE OF ANTI-FERMENTS—NECESSITY OF CHEMICAL KNOWLEDGE—CONCLUDING APOLOGY—THE POET'S EULOGIUM—THE BREWER'S LEXICON.

Not a little judgment is required, on the brewer's part, to ascertain the precise time when a gyle or vat of malt liquor is in the fittest condition to be racked off for consumption; and the manner in which it is commenced and completed is of some consequence; for the most objectionable constituents of the decomposed fluid have either naturally or designedly been carried to the bottom of the square or other vessel containing the beer; and as the racking tap, or a loose tube in its inner end, is made long enough to project some few inches above the bottom of the vessel, for a good and specific purpose, such means as are beneficially applied to aid the main object should not be frustrated, nor should other useful provisions be neglected. Hence the use of such materials as will remove the cause of cloudiness as precipitants, and will keep the sediment stagnant; and hence the utility of a more perfect racking-engine than such as are in ordinary use. Now, the only ingredients that can be employed with manifest advantage in effecting clarification, are hops and isinglass,

the application of which is so simple that nothing needs be said in reference to the subject, were it not for an existing difference of opinion with respect to the former, and a little want of knowledge which allows some imposition in the choice of the latter.

Some brewers "hop down" with new hops, and others with such as are half-spent, whereas a third class use none whatever. The last-named of these customs is preferable to the second, but the first is the most judicious of the three, because a certain design is therein understood and acted upon, under the impression that it will produce definite results. They who have read the brewing treatises brought out by Black and by Roberts, will recollect that the former of these authors is a strong advocate for rousing the worts when in the hop-back, for the grand purpose, as he says, of disengaging the lupuline from the flower, that it may flow away with the worts, and protect them on the coolers; in doing which he has acted upon the advice of another; but the latter-named writer either denies the utility of this measure, or merely issues his *ipse dixit* in condemnation of the plan. Both parties may be right in a portion of their respective ideas, but neither of them has gone far enough into the subject, and especially Mr. R., to prove his position satisfactorily and fully, or indeed in any degree. (*See* page 290.)

It appears reasonable, and is likewise probable, that the rich nectarium residing in the lupuline is prevented by the dense worts from exuding through its fine porous prison wall into such worts; so that, in order to avail ourselves to the fullest extent of its antiseptic presence upon the cooler, we must, under the circumstances represented by Black, rouse the hop-back, that we may liberate these partially exhausted little pellicles, to float through the false bottom and run off in the wort. This

is reasonable enough, if only for the sake of economy; but it is more than probable that, beyond this, the mighty process of decomposition and amalgamation to which these additional portions of the hop are subject after they leave the coolers, is of more considerable importance than their previous effect on the coolers. It was probably the latter idea (though economy in contriving the plant may have weighed in the arrangement) that gave rise to the use of hop-nets, instead of backs, in some few country places; with respect to which ancient and almost obsolete, but excellent contrivance, a remark may be useful here. The hops intended to be consumed at a brewing are broken up, and loosely distributed in two or three fine but strong nets, or by some in wicker baskets, and suspended in the worts from pulleys placed a few feet above the copper, and just previously to turning out, while the wort is in ebullition, the hops are drawn out of the copper, and remain suspended over it, draining and waiting to be lowered into the forthcoming wort. Thus is Black's principle virtually carried out, and is perhaps open to further and deeper censure on the part of Roberts's admirers, though upon what plea, that author leaves us to guess. Mr. R. may not object to the hop-dreg in reality, but perhaps to some other. Can it be a malt-dreg, consisting of coagulated albumen, gluten, &c., or what? These are certainly kept back in very large quantities when the worts are permitted to filter unmolested through the hops. It must be borne in mind, that he advises that the worts may remain in the hop-back until the heat descends to 180°, before they are let run into the coolers; and in doing this he is, no doubt, actuated by the same reasoning, to give time for the deposition and entanglement of the feculences amongst the leaves of the hops; and undoubtedly the

properties he wishes to avoid consist of a superfluity of perishable and contaminating albuminous gluten, starch, and other unconverted matter of the grain; but why does he not speak out with that candour and confidence which he can shew elsewhere, and for which his literary and scientific countrymen are especially distinguished? Perhaps his modesty interposed.

It must be evident that half-spent hops cannot be of much utility in malt liquors after racking; for whether all their *stamen* be roused out of them by the Blackites, or whether they be surcharged by the refuse of the grain, the pristine promoter of acidity, as recommended by the Robertsian school, they are equally objectionable in either way, in any liquor that is intended to be bright and sound; and, besides, it is wasteful in another way; for they generally retain a richer fluid by absorption than that which they are intended to preserve. These are the reasons why dispensing with hops altogether is preferable to using those that are half-spent; and as some considerable benefit arises from the use of hops at racking, none but new ones should ever enter a bung-hole or a man-hole; for the attributes which they possess of entering into affinity with floating atoms, of caustically subduing gluten, &c., and the antiseptic nature of their oil and resin, then in full vigour and action, render it important that no others should be employed, because they would be destitute of the prime essentials for effecting the purpose in view; but, were it not for legislative prohibition and public prejudice, equally efficient and harmless ingredients could be used to the same advantage, and with greater economy.

Whatever be the modes of fermenting and storing malt liquors, or indeed any others, that will still be a matter of choice, dependent on taste, locality, means, and management; but racking will generally be found

a necessary act, prior to ultimate transition. Frequent racking, on the contrary, must be injurious to any fermented liquor, because it thereby not only incurs flatness by the expulsion of its carbonic acid gas and ether, but is exposed to atmospheric air, and consequently to its dangerous oxygen; and this element does not remain in a latent or primitive state, but instantaneously or eventually, according to the amount of caloric present, unites with either the alcohol or the carbon, forming acid and renewing the gas, and thus at the expense of the body, spirit, and flavour of the article; and by the power of secondary action, the decomposition and dissipation of the most desirable properties of the liquors are facilitated, and the road to destruction is gradually run, as the rackings are repeated.

Having advanced these arguments in favour of a final racking after a state of quiescence in store, the author, that he may ensure a permanent and brilliant beverage in the hand of the consumer, begs to introduce to his readers his last little invention, which, though simple in itself, is nevertheless an integral part of his Patent Brewing Apparatus, without which his prescribed system of perfecting his beverage would not be complete; neither is it by any means so trifling in importance as it is simple in construction, inasmuch as by it the misfortune of disturbing the sediment of the liquors during racking is totally avoided. This instrument he has denominated

The Floating Racker.

This little and cheap contrivance is constructed and acts as follows:—A tube a few feet long, made of caoutchouc, for the advantage of elasticity, though a light metallic one will answer the purpose, is bent at right-angles, or jointed, if need be, so as to have a square

elbow at some eight inches from its nether extremity; this end is inserted into the inner orifice of the racking tap, and the upper is closed and mounted with cork, or with a spherical metallic buoy, similar to the float used with a ball-cock, or indeed with any other substance that will swim upon or near the surface when the tube is immersed. A little below this buoy the tube is perforated by a hole on each side, or perhaps two, if found desirable. When it is intended to rack off the contents of a fermenting square, store-vat, or other vessel, while the racking tap is turned on, the liquor will flow through the bent tube, entering into it by means of these perforations; and as the quantity of liquor left in the square or other vessel decreases, so will the apparatus gradually lower, and by means of its buoyancy maintain a proper position throughout, permitting the uppermost and finest of the beer to pass freely away, without any admixture with the grosser particles below, or with any refuse that may rest on the top.

The author has no better opinion of too many hoppings than he has of too many rackings, though some brewers may recommend and practise "hopping in the vat,"—"hopping in the cask,"—"racking into the vat for stores,"—"racking from the stillions for sending out;" and, again, "racking for immediate use,"—"general hopping,"—and "racking in general,"—enough to frighten a person of ordinary nerve. The "disagreeable rankness" which Levesque would dissipate by repeated hoppings, he thereby increases, through the rawness of the antidote; and moreover many rackings, like those that are used to torture animals, dismember the body till it becomes lifeless. The less locomotion and shifting malt liquors undergo, the sounder will their constitution continue to be. It was a just observation made by Richardson in his instructions of old, that whether ale

were racked from vats, or merely from cask to cask, the operation gave it a tendency to go flat. He preferred the use of three pints or two quarts of warm hops which had passed through the first wort, to be added to each barrel three or four days from cleansing; but he admits that "the hops thus added give some rankness to the flavour;" therefore, in advice on racking "keeping ale," he does not hesitate rather to promote the practice of mixing the old with "a sixth to a fourth part of new ale, taken from the gyle-tun, in a state fit for cleansing," which he would purify by filtration through a flannel bag, and says that a quart to the barrel added in this way, raised it from flatness till "it produced all the liveliness of bottled ale, without having in the least injured its purity:" but the experiment will not always prove successful; and it seems that he "had little occasion to pursue the practice."

In order to expedite the depuration of malt liquors, and to clear them from that turbidity consequent to the first fermentation, particularly under mismanagement, changeable weather, or imperfect materials; and to prevent a further decomposition of the turbid particles, and stop their influence over the remaining saccharum and saccharific parts; it is commonly found necessary to add a precipitant whose affinity for the glutinous particles is greater than that exerted by any other principles in contact. The substance used to perform this is *gelatin*, from its purity and aptitude for the purpose, as well as being an allowed commodity. This substance exists in a variety of forms, but is always prepared from the solid parts of animals, such as their tendons, cartilages, skins, hoofs, horns, &c. The ultimate elements of that species of gelatin which is commonly termed *isinglass*, are C. 50·557, O. 23·750, H. 6·903, N. 18·790,

as given by Scherer, and copied by Liebig, who remark that gelatinous tissues generally have a similar composition; hence another analysis of good gelatin has C. 47·8, O. 27·4, H. 7·9, N. 16·9. It is a nutritious article of food in certain conditions, soluble in water and most of the acids, but not in alcohol, and its solution is facilitated by heat.

Isinglass, which is the preparation used by the brewer, is derived from the Dutch *hyzen*, to hoist, and *blas*, a bladder, and is therefore an English corruption of *hyzenblas*, an air bladder, which was its original signification in its native tongue. When first brought into this country from the shores of the Black and Caspian seas, where it was manufactured by the Tartars from the *swims* or *sounds* of the *acipenser*, a species of sturgeon, it was called *fish glue*. The skins, fins, and tails of other fishes, were afterwards found available; and in 1763, a Mr. Jackson took out a patent for making "British Isinglass" from such as he chose to call British materials, and in 1765 he wrote a book on the subject, in which he complained that, in consequence of a prejudice raised against his article, he could only sell about 6 tons a year, though the brewers used 25 tons. This appears to have been *book* isinglass, so called from the skins or other materials being folded like leaves in a book. Many years afterwards, the chief distinction in this commodity was into *long staple* and *short staple*, according as it was produced from large or small fish, or such parts of fish. At present, the best is said to be imported from Russia, where the sturgeon retains its celebrity. The price depends as much upon the form and the degree of its purity as upon its intrinsic worth. The principal varieties, besides the staple and the book, are *leaf*, *pickings*, *cross-key*, *purse*, *pipe*,

soleskin, &c. &c., as the pieces are folded or produced, of which the most profitable, considering price, produce, and effect, are—

Of the finer sorts, Russian pickings and fine leaf; and of the commoner kinds, soleskins, which are used to much advantage, effecting great economy in many large establishments in town. Isinglass, and especially the inferior, should always be examined, and all the damaged parts, or such as smell offensively, should be carefully picked out or pared off, and thrown away.

The usual method of dissolving or "cutting" isinglass, which is sometimes also the most convenient mode, is by steeping it in sour beer, such as returns, or a kind which is brewed and acetified for the purpose. The smaller the quantity of acid *that will properly cut* the glass, the better for the beer fined with it: it should pass through a fine hair-sieve without much rubbing, and the necessary degree of solution should then be made by adding fresh table-beer, rather than anything containing acids or disagreeable flavours. From experiments made in dissolving isinglass in the various acids, both concentrated and dilute, the vegetable kinds, such as the *acetic* and tartaric, operate the most readily, and in proportion to their relative acidity. These acids act merely as solvents, whereas the action of those from mineral bases, as the sulphuric, for example, is more strictly chemical, suddenly destroying the matter. The distilled acetic acid, although just double the price of ordinary *sours*, is the cheapest solvent of any, owing to its purity and efficacy: that which is the most highly concentrated may be added to weak returns, &c., with considerable advantage.

The inferior descriptions of isinglass require stronger acids than the best sorts, and are also much longer in dissolving; and it often happens that the acid disappears

before the common glass is half cut; in which case the liquid should be poured off the surface, and a sharper acid should be applied, often roused, and kept as close as possible.

This article, which generally forms an important item in the expenses of the brewhouse, may be considerably economised by being kept in air-tight casks, after being cut and sifted in the usual manner, being there improved by the retention of the acetic ether, and its more intimate connexion with the gelatin; and a more minute solubility is also aided by the internal pressure consequent on the confinement of the generated gases. The efficacy of this treatment and extension of time is first evinced by the equal distention of the gelatinous matter, and its disinclination to subside in the menstruum; and, in the next place, a much smaller quantity suffices in consequence.

This communication will be appreciated by the thoughtful; for to such it must be clear that the smaller the particles are, the greater is their number within any given bulk, and the more diffuse and diversified are the points of attraction presented to the particles of floating yeast; and each separate atom of glass being attenuated equally with the others, the more simultaneous, uniform, and complete, must be their desired action.

The quantity requisite will depend upon its consistence and the quantity of matter to engage it; considerations which are seldom entertained by the persons to whom the discretion of its application is usually entrusted. A quart to the barrel is about the universal *quantum*, and is often full 50 *per cent.* more than either porter or vatted ale requires.

No fresh malt liquor should be bunged down too soon, for if its brightness is not perfected before racking, the

pressure arising by the accumulation of heat and gas will re-dissolve the yeast and dross, which, immediately on the relaxation of the dissolving force, will rise and be again diffused through the bulk, rendering its depuration by the finings more difficult than before. No precipitant should be applied until the beer has reached its final destination, or, at the earliest, just before loading. Here it may be correctly observed, by the by, that it would be better for the Birmingham brewers were they to become less tenacious of their ancient custom in this particular; and it is again hoped that the repetition of a respectful hint will be as serviceable to the body as it has already been to one or two who know the result of attending to it. It would also be better not to fine a second time until the beer has been racked off its old finings and their accompanying lees; nor should any isinglass be ever used, except in beer that will not conveniently become bright without it. Finings of some sort are however admitted to have become almost universally necessary, and especially for new beer, and where the ales are hastened for ready consumption; for although some will become tolerably fine in a short time, they will not always so speedily brighten without some precipitant to clear them. Some beers are too stubborn to submit to isinglass, and can only be clarified when put under the surveillance of alum, or some other prohibited ingredient.

Wynn's Close Receiver.—This is an apparatus resembling the bellows of an organ, for which a patent was obtained in April, 1837, by William Wynn, of Dean Street, Soho, London, clockmaker, whose object is to diminish evaporation in vinous, alcoholic, acetic, and "other volatile" vapours, and to prevent the absorbing of noxious effluvia by such fluids as malt liquor, cider, perry, wine, spirits, or vinegar. The instrument is

"suspended in a proper frame" over any vat or cask, &c., when being drawn off for consumption, the upper side of the bellows being constructed so as to be lifted, and to fall in the usual way, or "according to circumstances." The two sides of the bellows are flexible, being made of Mackintosh cloth, joined at the edges by a caoutchouc varnish, except in cases of having to act upon spirits of turpentine, ether, or such other bases as will produce a volatile vapour solvent of the caoutchouc, where he substitutes leather and glue. The connexion between the evaporating vessel and the bellows or "receiver," is by means of pipes and stop-cocks, so contrived that as the vessels evaporate or emit gas, such vapour or gas, instead of escaping, is received into the bellows, which have a safety-valve on the top, and the stem is in contact with the frame.

The mode of action is this:—The liquors, as they are drawn off, "can" always be kept under a pressure sufficient to fill the casks, to obtain which the patentee inflates with carbonic acid by means of a force-pump, preferring the gas to atmospheric air; and as the bellows act, they draw in the escaping vapours till they reach the extent of their expansibility, when the safety-valve opens, lets out the surplus, and shuts as the bag collapses; and, of course, whatever is useful may be collected as it escapes through the valve.

Some people assert, and the idea is entertained by several distinguished brewers, that finings invariably float when the beer is in a fit condition to receive them, such as has just been treated upon, and that they descend only in stubborn beer: such an idea is not supported by direct experiment, for the principal portion of the finings gradually sink in all ales, and carry with them the impurities that come within the sphere of their attraction throughout the line of their descent,

while other particles of the glass of less specific gravity, and those that are overpowered by the buoyancy of the globules of carbonic acid gas that attack them, naturally swim on the surface, remaining there until their supporters disappear, when some of them again are disposed to fall downwards. Indeed, the specific gravity of the best isinglass is seldom exceeded by that of any malt liquor properly attenuated; consequently in these only, where seldom wanted, can the inferior kinds of finings descend.

Although transparency is the immediate object and effect of fining beer, the ultimate consequences of its operation are of equal moment with the formality of merely "pleasing the eye," the palate having likewise a pleasure of its own. One chief object is the preservation of the article from cloudiness and acidity; for the principal preventive of these maladies in a body properly reduced by attenuation, is undoubtedly a prompt and perfect removal of the most perishable among the constituents of the liquid, be it the extract of either fruit or corn.

Antidotal means and things in great variety have been proposed with the intention to check an undue decomposition; but few of them, even in skilful hands, can be advantageously used, or at all applicable to wholesale establishments: these are sulphate of lime, often before noticed, sulphate of potash, sulphurous gas, sulphuric acid, alum, pine resin, olive oil, oil of mustard, manganese, oil of turpentine, oil of creosote, oxalic and prussic acids, corrosive sublimate, verdigris, and red precipitate of mercury; a precious laboratory of poisons, which no respectable victualler would dare to touch, much less a brewer, whose thousands and tens of thousands are at stake equally with his honour and reputation. A careful and judicious mash and fermentation,

upon the principles that have herein been explained, will produce a sound, bright, and properly matured extract, adequate to every object of durability, without any foreign appliance whatever; though it may not be superfluous to remark, that whether the object of mineral or vegetable additions be to effect clarification, to maintain it, or to preserve spirituosity, a previous knowledge of the components of the brewing water employed is imperatively necessary before anything of the kind can be safely attempted; for to proceed in darkness is to risk the perpetration of injury far worse than the existing evil. For instance, to add alum to a fluid containing carbonate of magnesia, nitrate, muriate, or carbonate of lime, muriate of barytes, or any of the alkalies, will cause a mutual decomposition of those salts. A correct chemical knowledge of these matters would direct a right application, and in some cases to a very profitable extent, particularly in a brewery where custom is the only guide, as much in the preservation of beneficial agents naturally existing, as in the destruction of injurious properties; which fact is demonstrated in the following examples:—Alum will not affect the sulphates, as that of iron for instance, nor is it affected by them; sulphate of iron is incompatible with alkali, or carbonate of magnesia, or muriate of barytes; whereas both the nitrate and the muriate of the same lime decompose alkaline carbonates, carbonate of magnesia, and the sulphates, except that of lime: hence the danger of dabbling in chemical experiments without a chemical knowledge commensurate with the undertaking, and the necessity of taking a lesson from the celebrated comedian, who made it a rule *never to play a character till he could play with it.*

The author having now concluded all that he has practically to advance in illustration of the principles

and practice of brewing, must again bring his laborious volume to its close. In concluding, therefore, this review of the most important features of the various patented machines, plans, and implements, connected with the art of brewing, the proprietor does not desire to shield himself, or any of these his matured contrivances, which were studied within the few hours spared from his business, and snatched, as it were, from the bustling attractions of busier scenes; nor would he excuse his repeated or continued temerity by any subterfuge of incapacity: he has gone, if possible, more calmly than before through his examination of the art, and has had the gratification of seeing his machinery in beautiful operation, not only in old and new establishments in London, but in a great number of provincial breweries also, to the great satisfaction and delight of both proprietors and operators.

Hence, then, without egotism, he *knows* that by means of the Patent Brewing Apparatus, invented and erected by him, a stronger, a more wholesome, a more endurant, and a cheaper article of consumption, as stimulant beverage, can be produced from the same quantity and quality of materials than by any other extant process. To the world at large, then, he stands confidently prepared to say that he has not been actuated by mean or mercenary motives, nor by a love of popularity, but by a genuine desire to serve the community. He is aware that "Every tub must stand upon its own bottom," and in the language of the trade, though desirous to "keep the copper safe," and to be less "sparged with cold water," than he has been by some of the ignorant and indiscreet, he once again submits himself, his patent, and his book, for each to have its due share of encouragement, but no more; for by candour, plain reasoning, and the voice of experience, he is willing that

all three should be assayed, weighed, and measured. He sits down to soliloquise over another goblet of his own "sparkling bright," with the laureate Warton, while compiling his lexicon and index;* humming thus:—

> "Balm of my cares, sweet solace of my toils,
> Hail, juice benignant! o'er the costly cups
> Of riot-stirring wine, unwholesome draught!
> Let Pride's loose sons prolong the wasteful night:
> My sober evening let the tankard bless
> With toast imbrown'd and fragrant nutmeg fraught,
> While the rich draught, with oft-repeated whiffs,
> Tobacco mild improves: divine repast!
> Where no crude surfeit or intemperate joys
> Of lawless Bacchus reign; but o'er my soul
> A calm Lethean creeps; in drowsy trance
> Each thought subsides, and sweet oblivion wraps
> My peaceful brain, as if the magic rod
> Of leaden Morpheus o'er mine eye had shed
> Its opiate influence. What though sore ills
> Oppress, dire want of chill-dispelling coals,
> Or cheerful candle, save that makeweight's gleam
> Haply remaining; heart-rejoicing ale
> Cheers the sad scene, and every want supplies.
> * * * Let the tender swain
> Each morn regale on nerve-relaxing tea,
> Companion meet of languor-loving nymph.
> Be mine each morn with eager appetite,
> And hunger undissembled, to repair
> To friendly buttery, there on smoking crust
> And foaming ale to banquet unrestrain'd.
> Material breakfast! Thus in ancient times
> Our ancestors robust with liberal cups
> Usher'd the morn, unlike the languid sons
> Of modern days; no favour had the might
> Of Britons brave decay'd, had thus they fed
> With English ale improving English worth."

THE BREWER'S LEXICON.

The reference *a* to any page denotes that the subject is there analysed; *d.*, that the word is derived or defined; and *e.*, that its elements are chemically declared from authority. *T.* signifies technical, or belonging to the *art*, and not commonly derivable from books.

Acclination, from *ad* and *clino*, to bend or lean towards; travelling in a certain direction, 166.

Acerbity; acer, sharp or sour; harshness of manner, 132; sourness of taste, 504.

Acetify; from the same, and *fio*, to be done; to become acid or sour, 45. 555. 514.

Acetification; act of souring, 140. 198.

Acetous; from *acetum*, vinegar, same root; containing sourness, 47. 201.

Acidify; to cause acidity, 196.

Acidulate; to create a little acid, 404.

Acidulous; containing *some* acid, the termination *ulus* or *ulum* being subtractive of signification in the root of the word, 125. 542.

Acrospire; acer and *spira*, a wreath, turning, or twist; a wig, 65. 75. 81, 82. 91. 194. This word ought to apply to the root instead of the stem.

Adamantine; adamas, a very hard precious stone, of which Pliny mentions six species; roots *ad* and *amo, to love for* the sake of it; extremely hard and compact, 323.

Adjutant; ad and *juvo*, to render aid to, assisting, 498.

Adventitious; ad and *venio*, to come to; acquired by other than ordinary means, 79. 431.

Aërated, aër, air, filled with that fluid (*aërial*, 156), 284.

Affinity; ad, to or until, *finis*, the end; permanent alliance, 345; also at 99. 154. 307. 319. 357. 389. 390. 391. 430. 520. See also 407. 428. 532. 550, &c.

Agate; ago, to act, whence *agent*; a hard mineral compound of silicious nature, 323.

Albumen; albus, white; commonly the white of an egg; that portion of a seed which acts as its reproductive matrix, 292. See 22. 35, 36. 44. 52, 53. 472, &c.

Albuminous; containing albumen, 37. 63. 303. 315. 391. 408. 417.

Alcohol; pure spirit of wine, *d.* 421. This word and *alcoholic*, dependent on alcohol, occur 70 times.

Aldehyde; dehydrated spirit, *d.* 422. See 392. 431. 467—470.

Aldehydic; arising from aldehyde, 470.

Aldehydinous; partaking of aldehyde in composition, 470.

Ale; nutritious beverage, *d.* 10; 40 occurrences.

Alegar; ale degenerated into acid, *d.* 470.

Alkali; *al*, as at 421, and *kali* (Arabic), sea-weed called glass-wort, from its use in making glass; a powerful chemical preparation, 35, 36. 112. 118. 539. 560.

Alkaline; consisting of an alkali, 56. For these words, see 60. 105. 123, 124. 126, 127.

Alumina, or *alumine*; alum, 110, 128. 130; also 63.

Aluminous; containing alum, 66.

Amalgamation; *ἁμα*, with, *al*, the whole; *γαμεω*, to marry; a consolidation of several in one, 140. See 504. 530. 549.

Amber; native word; light brown; a peculiar colour in malt, next to pale in its shade, 501. See 151. 487. 494. 500. 513.

Amidin; *αμ* and *ιδιν*, same as *ιδια*, a word expressive of privacy; the interior of starch, 39. See 52. 59. 94. 173. 179. 445.

Ammonia; *αμμος*, dirt; fœtid matter, the essence of manure. Some derive it from Jupiter Ammon, and pronounce it urinous, 55. Occurs also at 60. 128, 129. 140.

Amorphous; *α*, negative, and *μορφη*, form; shapeless, or of any shape whatever, 60.

Amylaceous; containing amylin, 172. 516.

Amylin; *α*, negative, and *μυλη*, a mill; unground, not dissolved; the shell of starch, *d.* 39. 42. 170.

Amylous; having the properties of amylin; in globules, 359.

Anhydrate; *αν*, negative, and *ὑδωρ*, water; deprived of water, 113.

Anhydrous; destitute of water, 322.

Animo-vegetable; partaking of properties common to plants and animals, 28. 50. 55. 58.

Annihilate; *ad*, to, *nihil*, nothing; utterly to destroy, 70. 284.

Anomalous; *αν* and *ομαλος*, equal; discrepant or contradictory, 234.

Anthracite; a peculiar kind of coal that burns without flame, 85. *d.* 29. Αν and *θρασσω*, to move.

Antiseptic; *anti*, against, *septicus*, putrefactive; preventing decay, 119. See 399. 438. 542. 548. 550.

Apotheme; *απο*, from, and *τιθημι*, to place; a substance deposited from another, 49.

Apparatus; *ad*, for, and *paro*, to prepare; machinery employed in conversion, 3; occurs 33 times more.

Aqueous; watery; from *aqua*, water, 60. See again 167. 271. 528. 545.

Argil; *argilla*, clay; properly a white kind called potter's earth, *d.* 126.

Article; from *ars*, power, come *artus*, a joint or limb, and *articulus*, a small one, or a part where *artus* expresses the whole; a finished preparation, 346; found in 26 other places.

Astringent; *ad*, to, and *stringo*, to tie or collect; of a binding nature, 272.

Attemperator; *ad*, to, and *tempero*, to rule, regulate, or alloy; a regulator of heat by creation, diffusion, or abstraction, 147—153; variously applied at 74. 144. 150. 155. 160. 162, 163. 170. 172. 176. 180. 190. 200, 201. 204, 205. 222. 281. 292. 346. 394. 403. 451. 453, 454. 516. 519, 520, &c.

Attemperated-tion, 172. 174. 178. 394.

Attenuate-ation; *ad* and *tenuo*, to thin or make slender; decrease of gravity by fermentation, 114; 22 other occurrences.

Automaton; *αυτος*, self, and *μαω*, to seek; a self-acting machine, 385.

Axiom; *αξιος*, worthy; that which is self-evident, 68. 435.

Azote; nitrogen, so called from killing all animals that breathe it alone; *α* and *ζωη*, life, *d.* 29.

Azotic; consisting of azote; azotised, implanted with azote, 60, 61. See 55. 70. 173. 244. 305. 408. 520.

Back; *T.*; any fixed vessel used to hold liquor or must, before, after, or intermediate to mashing or fermenting, 265; occurs variously at 123. 194. 261. 286. 316. 346. 517. 548, 549.

Barm; yeast wrought upwardly, *d.* 9; see 390. 393. 395. 398. 406—408. 412. 439. 455.

Barrel; *T.*; 36 gallons; no other application is correct, 140; repeated in 30 other instances.

Beer; malt liquor of any kind, *d.* 9; 67 repetitions.

Bicarbonate; *bis*, twice, and *carbo*, which *vide*; doubly carbonated, 110. 130.

Blow off; *T.*; to purge a cask, 540.

Blowing off; *T.*; expulsion of ether from the worm of a still, 426.

Blown; *T.*; malt puffed up by a regular process, 89; see more at 485. 500.

Boas; serpents that entwine round objects or each other, 75.

Brew-ed-er-ery-ing; preparation by infusion, *d.* 11. 12; appears with various inflections 295 times.

Broach; *T.*; to tap, or otherwise to open a cask, 540. 550.

Bung; *T.*; a large cork, 19. 556; also a term for a brewer, *Dedic.*

Bunghole; the orifice in which a bung is fitted to a cask, 540. 550.

Butt; *T.*; three barrels in capacity, 524.

Calcareous; *calcarius*, pertaining to lime, 66. 139. 341. 542.

Caloric; *calor*, heat, from *caleo*, to be hot; the matter of heat, 22; and in 25 other places.

Calorific; *calor* and *fio*, to be done; producing caloric, 22. 155. 520.

Carbon; an ultimate element, *d.* 29; 20 repetitions occur.

Carbonaceous; consisting of carbon, 509.

Carbonate; from *carbo*; a mineral salt in effervescent powder, 128; repeated in 20 places.

Carbonic acid gas; an aëriform fluid, derived from the admixture of oxygen and carbon, 73; is in 28 other places.

Carbonise-ed-ation; reducing to carbon, or blackening into cinder, 290; see 284. 293. 498. 501. 509, 510. 518.

Carburetted; *carbo* and *uro*, to light up or set on fire; street gas, 427.

Caromel; colouring matter, *d.* 497; term misapplied, 506.

Caustically; *causticus*, able to burn, irritating, 117.

Censorious; *censor*, an exactor; speaking with severity, 5. 358. 561.

Chalybeate; *chalybs*, steel; hardened by native iron, 125.

Char; *T.*; to blacken by heat, 31. 263. 494. 545.

Charge; *T.*; to fill a vessel, 87, 88. 259.

Chimera; *chimæra*, a poetical monster; an unattainable end, 138.

Cleanse; *T.*; to clear an article from barm, 310. 346. 437. 458. 461. 519. 544. 553.

Coagulate-ed-ation; *con*, together, and *ago*, to act, with the diminutive termination; to adhere together in small quantities, 22; repeated or inflected 13 times.

Cockspur; *T.*; having a sharp point like a cock's heel, 96, 97.

Come off; *T.*; to quit a tun after process.

Commings; *T.*; rootlets and particles detached from malt, 96.

Concatenation; *con* and *catena*, a chain; a linking together, 201.

Concentrate-ed-ation-ing; *con* and *centrum*, middle point: rendered pure and compact, 162; occurs 18 times.

Condition; *condio*, to season; the farina of hops in maturity, 255.

Congelation; *con* and *gelu*, frost; hardening together, 338.

Connoisseur (French), a person of accurate taste, 144. 484.

Consignificantly; *con* and *signum*, a sign, with *fio*; meaning the same thing, 214.

Contagion; *con* and *tango*, to touch; acquired by touching together, 79; see 143. 391. 404. 445. 479. 531.

Contraband; a mongrel word, signifying contrary to bond or law, 37.
Copper; T.; a circular boiling back, 58; 17 repetitions occur.
Copperside; T.; the interior of a brewery, 3.
Coppersmith; who *smiteth* copper, 265. 286.
Correptious; con and *repo,* to creep; rebuking slily, 508.
Corrugated; con and *rugo,* to rumple or wrinkle; laid in folds, 387.
Cosine; a trigonometrical sine is a perpendicular upon the diameter of a circle, demitted from the extremity of any arc whose other termination is the end of that diameter; and the cosine is the distance from the sine to a second diameter drawn perpendicular to the former, 364. 367, 368.
Cotyledon; part of a kernel, *d.* 49; see likewise 51. 65. 78.
Couch; T.; a frame for draining barley after steeping, 53, 54. 73. 76. 84.
Cream; T.; a light compact substance on the surface of wort or ale, 313.
Cryptogami; κρυπτω, to conceal, and γαμεω; an accumulation of matter latent within the pores, 542.
Crystallised; made bright like crystal, 92.
Cuticle-ular; cutis, skin; diminutived; having a thin skin, 45. 47; also 101, 102.
Cutting; T.; dissolving isinglass, 555, 556.
Cylinder; cylindrus, properly a roller; any round vessel of uniform width, 89—91; see 271. 348. 500.

Decapitate; de, from, and *caput,* the head; to take the head off, 47.
Decimation; decem, ten; dividing into tenths, hundredths, &c., 64.
Decrement-al; de, negative, and *cresco,* to grow; decreasing by a gradual law or rule, 318. 334. 365. 370. 310.
Deliquescent; de, from, and *liquesco,* to melt; becoming soft or liquid, 293.
Demeteric; 529, *d.* 430.
Density; 23. 105. 117. 131. 148. 156. 161—163. 193. 195. *d.* 215; and 20 more places.
Depuration; de and *purus,* pure or clean; fining beer, 553. 557.
Desiccated; de and *siccus,* dry; rendered solid, 131.
Devisal; de and *video,* to see; seeing for, contrivance, 183.
Dextrine; dexter, the right; so called from its peculiarity in polarising light, 152. 172, 294.
Diastase-tatic, occurs 41 times, *d.* 58.
Dogma; dogma, a decree; received opinion, 5.
Dreg; T.; dust and refuse of malt or hops, 416. 418. 549.
Dynamic; dynamis, power; great or perfect, 413, 414.

Ebullient-ition; e, from or out of, and *bullio,* to boil; bubbling up, 7; see 141. 156. 265. 283. 295. 297. 289. 328. 549.
Egotistical; ego, I, and *iste,* this; abounding in self-praise, 180.
Eliminate; e and *limes,* a bound or limit; to release, 61.
Empty; emptus, from *emo,* to buy; bought out; technically a cask from which the contents have been abstracted.
Empyreum-atic; ἐν, in, πυρ, fire; tasting as if burnt, 263. 484.
Entire; all of one quality, 163. 483.
Equator-ial; æquo, to make equal; an imaginary plane, dividing the earth, &c., into north and south, 334. 338.
Equinoxes; æquus, equal, *nox,* night; time of equal day and night, 362. 366.
Eremacausis-tical; 333. *d.* 389. 399; see 408. 422. 432. 499.
Ether-eal-ise; properly pure air; from *æther,* the region of the sky; a volatile liquor, transparent, colourless, fragrant, pungent, and light, boiling at 98°, or *in vacuo* at 20°, 39; read in 24 places.
Euphony; ευ, well, and φωνη,

sound; an agreeable arrangement in pronunciation, 48.

Examen; Lat. signifies a flock, shoal, or swarm; any substance under test or trial, 215.

Excrementitious; *ex* and *cremor*, a thick juice from barley; substance cast out by fermenting, 519.

Extract; *ex*, out, and *traho*, to draw; any thing drawn out, 3, 4; occurs 64 times.

Extractive; same roots, 27. 48. 395; see also 58. 122.

Fæcula; dimin. of *fæx*, sediment; grated potato, 35. 37. 38.

Fæculencies; resembling *fæcula*, 549.

Farina-ceous; Lat. flour, dust, 27; found in 34 places.

Ferment; *fermento*, to leaven or make light, *d*. 388.

Firkin; *T*.; nine gallons, or quarter of a barrel.

Flakes or *flocks*; *T*.; albumen, &c., 53. 62. 127. 288. 295.

Flange; *T*.; a flat rim round the end of a tube, to secure it on the outside by bolts or screws, 348.

Flints; *T*.; hard unmalted corn, 80; see 98. 66. 175, 176.

Flocculent; *flocculus*, a small flock of wool; containing flakes, 291.

Floor; *T*.; the bottom of an utensil; likewise a steeping of malt at a certain stage of its process, 74. 96. 155. 261. 496.

Flush; *T*.; a bright brown colour, peculiar to the best porter, 485.

Fob or *cauliflower*; *T*.; frothy head.

Fox; *T*.; a very foul and rank taste and odour in malt liquor, 284. 488.

Frame; the same as couch; also as 75.

Fret in; *T*.; to introduce alien matter during fermentation, 509.

Friable; *frio*, to crumble or break into small pieces; easy of severance, 65. 96.

Galvanic-ised; containing the principles discovered by Galvani in relation to electricity, 307; see modifications at 320, 321. 387. 460.

Gelatin-ous-ising; *gelatus*, frozen; a hardened jelly, 141. 151. 257. 554. 556.

Gelidising; *gelu*, frost; stiffening, 321.

Geological; γη, the earth; λογος, a discourse; describing the substances forming the earth, 109. 114.

Gill; a much disputed word, *d*. 249.

Glass; *T*.; isinglass dissolved, *d*. 554, 555.

Gluten; commonly glue or paste; see 27. 29, 30. 34. 36, 37. 45—8. 50. 55, &c.; also 62. 65. 79. 81. 86. 95. 117. 146, 147. 174. 201. 205. 532. 549, 550, &c.

Glutin; *glutinum*, a variation of gluten; more minutely distinguished at 46. 56. or 444. *e*. 553.

Glutinous; containing gluten, 41. 43. 53. 195. 532. 553.

Goods; *T*.; malt wetted in the mash-tun, 145, 146; refer to 148. 140. 153, 154. 178. 181, 182. 184. 186. 191—194.

Grains; *T*.; goods deprived of their juice, 185. 190. 192—196. 200. 202, 203. 209. 279. 302.

Graminous; of the nature of grain, *d*. 50.

Gramme; a French measure of weight, of which 454 are a pound avoirdupois British, 418.

Granular-ation; *granulum*, a little grain; resembling fine sand, 63. 304.

Gravimeter; *gravis*, heavy, and *metior*, to measure, *d*. 216.

Gravity; weight of wort above 1000 ounces to the foot, 130. 188. 469.

Grist; contraction of *grindest*, *d*. 101; 18 other places.

Gum; Lat. *gummis*, an adhesive convertible substance, *a*. 40; occurs in 30 pages under different circumstances.

Gyle; the quantity brewed from a mashing of goods, *d*. 189, and 28 other places.

Gypsum; Lat., white sulphate of lime or plaster, 113—115. 118. 122. 124.

Lymph; *lympha*, water; the matter of inoculation, 280. 412.
Lymphine; yielding lymph, 5.

Macerate-tion; *macero*, to soften by steeping, 42. 53. 60. 124. 143.
Magnesia-n; *μαγνησια*, from *μαγνης*, loadstone; from a property which it has been supposed to possess, 56. 109. 112. 116—118. 126. 128. 130. 250. 560.
Malt-ine-ing; *T.*; 10. 36. 47. 54. 63. *d.* 12; occurs in 32 other cases.
Manhole; *T.*; a hole large enough to admit a man, 454. 459 530.
Manipulate-ion-ing; *manipulus*, a handful; to pass through the hand, 66. 165. 177. 427. 485. 512.
Mantelshelf or *piece*; Old Fr., work raised before a chimney to conceal it; shelf over a fireplace, 211. 413.
Mash-ing; any infusion of goods in liquor, or the mode of using them, 12. 20, 21. 23. 59. 70. 139. 153. 159. *d.* 11.
Matriculate; dimin. of *mater*, mother; a collegiate term to express progress in education, 19.
Mawkish; *T.*; flat and insipid, 142. 178. 433.
Mead; Old English for *meadow*; a liquor prepared from honey, 9—11. 13. 287. 492.
Medicamentous; *medicamen*, inward or outward medicine; cordial, healing, dispelling pain, 515.
Mellow-ness; freedom from harshness of taste, 145. 528. *d.* 505.
Menstruum; *mensis*, a month, *struo*, to flow. In its Latin application this word signifies "a monthly allowance for maintenance," and, as the representative of plain *water*, is grievously and irregularly misapplied, 106. 336. 556.
Mephitic; *mephitis*, a damp or foul gaseous smell, 69. 80.
Meridian; *medius*, middle, *dies*, day; an imaginary great circle encompassing the earth over-head, directly north and south, 338. 379.
Metamorphosis; *μετα*, *trans*, passing over, *μορφη*, form; a transformation, 146. 157, 158. 404. 427.
Metheglin; *μεθυ*, wine, *γελαω*, to laugh; the cheering drink of the ancient bards, 287. See *Mead*.
Millemetre; a French measure of length, 305 of which are an English foot; compounded of *mille*, a thousand, and *metiri*, to measure; a 1000th of a metre, or of 3 feet 3·34426 in. 417 *.
Mobile; Lat. *mobilis*, movable, 151.
Mobility; movableness, activity, 148.
Monopoly; *μονος*, alone, *πολυς*, much; engrossing a commodity by one person to sell it dear; various inflections at 38. 90. 122. 224. 226. 484. 520. 522.
Mucilage; *muceo*, to be flat or to abound with dregs, *d.* 41; variously applied 62 times. Castle's Lexicon defines mucilage a simple solution of gum in water, thick and adhesive.
Mucilaginous; consisting of mucilage, 20 applications, 37 to 532.
Mucous; *mucus*, slimy, 37.
Multifarious; *multus*, much, *fari*, for; in many ways, 144.
Muriate; *muria*, brine or pickle; a liquid salt, particularly volatile and brackish, incombustible, and little subject to the action of fire, 107, 108; see more at 111. 114. 116. 117. 126. 128—130. 560.
Muriatic; creating a muriate, 117. 127, 128.
Must; wort under fermentation, *d.* 249; appears 12 times elsewhere: also a foul earthy odour, 545.

* This was taken from the Englishman's Almanack for 1845, which states that a metre is 3 ft. 3·371 inches, 92 metres 100 yards, and 305 millemetres a foot, which results do not agree; for as 305 : 1 :: 1000 : $\frac{1000}{305}=\frac{200}{61}$ = 3 ft. 3·34426 in. :: 92000 : 3·0164 ft. = 3 ft. ·1968 of an inch; or it is 39·34426 x 92=36·1967 inches.

Nappy; T.; producing sleep, 495.
Narcotic; ναρκη, torpor, lethargy; producing numbness, 244. 493.
Nectar-eous; nectar, 438; in mythology, the drink of the gods; delicious, 9. 263. 438.
Nectarium; same root; in hops, 256. *d.* 548.
Nescience; ne, not, *scio,* to know; ignorance, 132.
Nicotin; nicotiana tabacum, tobacco; from *νικαω,* to overcome; essence of tobacco, 239.
Nitrate; nitrum, saltpetre; a crystal salt capable of supporting combustion, and furnishing, by the action of fire, oxygen gas mixed with azote, 111. 127—129.
Note—Carbonates, muriates, and nitrates, are severally formed by the combination of carbonic, muriatic, or nitric acid, with an alkaline, earthy, or metallic base, and each has three classes accordingly.
Nitrogen; one of the ultimate elements, *d.* 29; appears with its derivatives 21 times.
Nitrous; containing nitre, 128.
Nozzle; T.; a short spout, 544.
Nude; nudus, naked, 90.

Oar; T.; an implement formerly used to stir the goods in the liquor, 140. 144.
Oast; T.; a kiln for drying hops, 254. 273.
Oil; Lat. *olea,* an olive tree or its fruit, wh. *oleosus,* full of oily substance; an adhesive slippery liquid, 28, 29. 39. 41, 42. 50. 58. 65. 92, 93. 178. 198—200. 247. 259. 550. 559.
— *essential;* 271. 292.
— *fat;* 50, 51.
— *fixed;* 49.
— *olive;* 533.
— *volatile;* 49. 255. 257. 259, 260.
Oleaginous; olea and *gigno,* to produce; yielding oil, 241.
Olfactory; oleo, to smell, and *facio,* to make, do, or cause; having the sense of smelling, 283.
On; T.; charged with liquid matter, 315.

Outcast; T.; increase of bulk, 83, 84. 97.
Oxygen; an ultimate element, *d.* 29; repeated in 52 instances.
Oxygenated; supplied with oxygen, 192.

Panification; panis, bread, and *fio,* to be made; bread-baking, 411.
Paragon; παρα, beyond, besides; *αγω,* to lead; one who excels all others, 123.
Parallelopipedon; παρα, near, *αλληλων,* one another, *πιπτω,* to fall together or lie along; a solid with six plane surfaces, having each pair parallel or equidistant at every point, 455.
Paralysed; παρα and *λυω,* to loosen; debilitated in nerve, 80. 294.
Parenchyma; παρα, εν, and *χυμος,* juice or sap, from *χυω,* to shed or diffuse; a juicy inner skin, 51.
Party-gyle; T.; a mixture or division of brewings, 162. 186. 189.
Peepshow; T.; a childish amusing spectacle, 141.
Percolate; per, through, and *colo,* to cleanse or strain; to drop through, 22. 182.
Peripatetical; περι, round about, *πατεω,* to tread; travelling in a circle, 24.
Permeates; per and *meo,* to go or pass; to pass through; impermeable, 89. 120.
Petal; Gr. *πεταλον,* a leaf, from *πεταω,* to extend; the leaf of a blossom, 256, 257.
Petroleum; πετρος, a rock, or stone, and *ωλα,* perished; a kind of mineral pitch used by japanners, 257.
Phenomena, pl. of *phenomenon; φαινω,* to exhibit, and *μενω,* to remain; observed appearances, 53. 157. 333.
Philosophist; φιλος, a friend, *σοφιστης,* a skilful workman, from *σοφια,* wisdom; an irony, implying an ignorant pretender to philosophy, 297.
Philosopher; same roots, and Sax. *wer,* a man; a lover of wisdom;

435 ; see also 19. 40. 62. 108. 135. 166. 435.

Philosophical ; dependent on philosophy, 80. 205. 219. 399. 486.

Philosophy ; love of wisdom, 2. 19. 29. 78. 185. 219. 280. 336.

Phosphate ; a salt formed by phosphoric acid with a base as before. The phosphates are crystallisable, fixed, fusible, vitrifiable, phosphorescent, and soluble in nitric acid without effervescing, but are not decomposable by charcoal, 28. 46. 50. 57, 58. 63. 92. 117. 285. 293.

Piece ; *T.* ; a quantity of malt collected on a floor, 74. 76. 78.

Pirated ; *pirata*, a robber ; stolen, 206. 259.

Pitch ; *T.* ; to put yeast to wort, 284 ; see 114. 212. 370. 393. 437. 440. 472, 473. 520.

Plant ; *T.* ; arrangement of utensils in the brewery, 150. 192. 516. 549.

Plumula ; Lat. a little feather ; first shoot in vegetation, 45. 47. 65. 81. 96, 97.

Phosphoric ; producing phosphorus, 127. 250.

Ponto ; *T.* ; a small secondary fermenting vessel, 346, 347. 438. 461.

Porter ; *porto*, to carry, *d.* 483 ; see 133. 182. 253. 482. 517. 524. 527.

Porter malt ; black malt, 41. 90. 100. 496. 500. 582.

Postulate ; *post*, after, dimin. gives *postulo*, to require ; that which we admit can be done, 539.

Potable-ation ; poto, to drink ; that which a person may drink, 19. 238. 500.

Precipitate-ion-ant ; *præ*, before, and *caput*, the head ; originally headlong. To throw down, applied in 27 places, 34 to 557.

Prime ; *primus*, first ; of the best quality, 480. 528. 550.

Problem ; προβλημα, from προ and βαλλω, to cast ; a performance proposed, 269. 432.

Propagator-tion ; προπας, the whole, from προ, before, and πας, all, to which is added αγω, to act ; that acts so as to produce, 542.

Proteic ; *Proteus*, a sea-god, who could transform himself into any shape ; changeable, 419.

Pseudo (brewers) ; ψευδω, to deceive ; mere pretenders, 310.

Pulverulent ; dimin. of *pulvero*, to dust over ; consisting in a fine dust, 239. 271.

Pyrometrical ; πυρ, fire, and μετρον, measure ; employed to ascertain the heat of fire, 323.

Rack ; *T.* ; to draw off beer from a vat or cask, 437. 521. 530. 533. 534. 547.

Racker-ing ; 547. 550, 551. 556.

Radiating ; *radio*, to emit rays ; dispersing influence, 22. 265.

Radicle ; dimin. of *radix*, root, 65. 74. 81. 91.

Refrigerate-tor-tion ; *re*, again, *frigeo*, to make cold ; to reduce temperature, 105. 336. 344—356 ; also at 385. 430. 451. 471. 504 516.

Reins ; *T.* ; the guidance of those employed in the brewery, 123. 561.

Replenishment ; *re*, again, *pleno*, to fill, 530, 531.

Resin-ous ; *resina*, an exuding gum ; twenty-one applications, 50. 559.

Retrogressive ; *retro*, backward, *gradior*, *gressus*, to walk, going back, 529.

Return wort ; *T.* ; a weak wort blended with the following mash, 186. 188. 1 96. 200. 248. 301. 555.

Rope-iness ; *T.* ; a viscid substance in beer, 532, 533.

Round ; *T.* ; a cylindrical fermenting tun, 434. 453.

Rouse ; *T.* ; to agitate briskly, 533. 548. 556.

Rule ; *T* ; a peculiar species of oar.

Saccharific-fier-ed ; *saccharum* and *fio* ; producing sugar, 36. 147. See further, 51. 158. 553. 101.

Saccharine ; consisting of sugar, 33 times repeated, 4. 5. 26. 31, &c.

Saccharise-ing-ation ; conversion into

saccharum, 146. 165; modified in 13 other places.

Saccharometer; saccharum, metior, to measure, or set out, 28 repetitions, 88 to 478. 80.

Saccharometry-etrical-etrians; 210. 214. 216. 222. 227. 229, 230. 233. 301.

Saccharum; sugar in fluidity, *d.* 32; repeated 55 times.

Saccharum of rye, 45.

Safe; *T.*; a place of preservation, 455. 459.

Saline; *sal*, salt; containing salts, 107. 115. 123. 125. 130. 132. 285.

Selenite; *selenites*, an Arabian stone, becoming more or less white as the moon fills or wanes, identified as a species of gypsum, 113.

Serial; *series*, connected order; proceeding by a regular law, 223.

Sesquicarbonate; *sesqui*, half as much added, and *carbo*; a common carbonate further digested, 130.

Set; *T.*; to become pasty, like dissolved starch or sago, 22. 41. 52. 100. 141. 494.

Set tap; *T.*; to turn a cock, that the liquid may flow through it, 20, 181. 190. 261, 262. 291.

Shive; *T.*; a wooden bung, usually cut level with the surface of the cask, 521.

Siccous-city; *siccus*, dry; *siccitas*, dryness, 207. 316.

Silent; *T.*; unemployed, 312.

Silica; *silex*, flint, 107. 110. 395. 417.

Singlings; *T.*; foul and weak liquor from a still, 426.

Slack, or *slacken*; *T.*; to diminish heat.

Sleepers; *T.*; corn that will not germinate freely into malt.

Solanin, essence of potato, *d.* 36. 38.

Solstices; *sol*, the sun, *sto*, to stand; when the days are longest or shortest, 362.

Sophisticated; σοφιστης, a deceiver; disguised by fraud, 241.

Sparge; to sprinkle, 161. 181, 182. 494, 495. *d.* 189.

Sparsion; act of sprinkling, 200. 263.

Specific gravity; *specio*, to view, and *fio*; with *gravis*, *d.* 214, absolute weight, 39. 122. 130. 235. 236; mentioned 19 times more.

Spigot; *spico*, to sharpen; a plug used to stop an orifice in a vessel, 350.

Spin; *T.*; to obtain too much length, 485.

Spissitude; *spissus*, thick, clammy; clogginess, 170.

Spumous; *spumo*, to foam; exhibiting froth, 484.

Square; *T.*; a four-equal sided and equiangular prismatic vessel, 354. 434. 439. 520. 552.

Starch; Sax. *starc*, stiff; a stiff substance produced from farina, *a.* 39, 40; convertible into saccharum, *d.* 34; named in 58 occurrences.

Start; *T.*; to run from one vessel into another.

Starting back; *T.*; a vessel to receive beer when running from the fermenting tuns.

Steely; *T.*; hard, so as not to submit to solution, 67. 86. 176.

Steep-water, or liquor; *T.*; that in which barley has been steeped for malting, 45. 65. 71, 72. 517.

Stillion; *T.*; a trough to catch the overflowings from fermenting casks, 438. 540.

Stingo; *T.*; containing sting or pungency, 253, 480.

Stinker; *T.*; an offensively foul cask, 537.

Stoker; *T.*; the workman at the fire, 210. 265. 442.

Store; *T.*; stock kept on hand, 71. 88. 173. 312. 386 390. 434. 458. 530. 531; also a Scotch term for barm.

Stout; *T.*; strong superior porter, 70. 495. 513. 514. *d.* 486.

Stratification; *stratum*, a bed of thickness, or layer, and *fio*; formation of the earth into successive beds of materials one above another, 108.

Strig, or *strombile*; *T.*; the stalk on which the hop flower grows, 257.

Subcarbonate; *sub*, under, and *carbo*; so called from some of the

INDEX TO ACTS CITED.

INDEX TO ANALYSIS.

INDEX TO AUTHORITIES QUOTED OR DIRECTLY REFERRED TO.

INDEX TO LATINITIES.

INDEX TO SPECIFIC GRAVITIES.

INDEX TO TABLES.

INDEX TO HEADS OF SUBJECTS.

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INDEX TO PLACES AND PEOPLE.

THE END.

GILBERT & RIVINGTON, Printers, St. John's Square, London.

JUST PUBLISHED,

A

VOICE FROM THE MASH-TUN;

BEING

A DISSERTATION ON THE RECENTLY-DISCOVERED

PRINCIPLES OF

SACCHARIFICATION

IN THE

MASH-TUN OF THE COMMON BREWERY,

BY THE IMPROVED MODERN PROCESS, FOUNDED ON THE UNERRING

DOCTRINES OF PHILOSOPHY;

WITH A

Description of the Patent Apparatus;

AN ANALYSIS OF THE REFINED AND INCREASED EXTRACT, PRODUCED BY

ITS ACTION IN THE MASH;

OLD AND NEW BREWING SPECIMENS; AND

A COMPARISON OF PROFITS.

By W. L. TIZARD,

PROFESSOR OF BREWING, AND BREWERS' ENGINEER,

LATE MANAGER AT THE NINE-ELMS BREWERY, LONDON,

PATENTEE OF THE MASHING ATTEMPERATOR, &c. &c.,

AND AUTHOR OF THE

"THEORY AND PRACTICE OF BREWING ILLUSTRATED."

LONDON:

SOLD BY THE AUTHOR.

1845.

Price Five Shillings. Q q

TESTIMONIALS.

THE following gratifying testimonials from brewing establishments in various parts of the kingdom, by gentlemen who have perused the former edition of this work, afford a more ample estimate of its character than the author can presume to express in language of his own. The places where they were written are arranged alphabetically, that all show of preference may be strictly avoided.

ALBAN'S (SAINT), Herts.—"I have not read the whole of the work, but have seen sufficient of it to convince me, as a brewer of some experience, that it is the most practical and scientific work on the art of brewing that has yet been published; and the discovery of the *Attemperator*, if it can be worked in the manner described, and also of the *Hystricon*, are the most useful and beneficial that have been made in the brewery for many years.

"DAVID HEELSON."

To the same effect are the expressions from the following; all of whom, with Mr. Heelson, can now be respectfully referred for proofs of the efficiency of the *Attemperator* to several eminent establishments, on production of the author's card, which he will be happy to furnish on application.

CANTERBURY, Kent. For Mr. Delmar .	"E. COWELL."
DURWESTON, Dorset (near Blandford) .	"H. GODWIN."
FOLKESTONE, Kent.	"H. TITE."
PORTSEA, Hampshire	"GO. GUYATT."
SALTASH, Cornwall	"EDMD. WEBB."
WOODBRIDGE, Suffolk	"WILLM. LOCKWOOD, Jun."

ANDOVER, Hants.—"I have very great pleasure in enclosing a P. O. O. for 25*s*., the amount of your valuable Treatise, which I have read with much interest and delight. It is full of useful information, and I most sincerely hope all your plans may be fully accomplished. JOHN POORE."

Similar in language and sentiment are the communications received from the undersigned:—

BATH, Somerset (Northgate Brewery) .	"H. AIKMAN."
BRECON, South Wales	"T. BASKERVILLE JONES."
HERTFORD	"J. L. MEDCALF."

HULL, Yorks. (Prynne's Wharf Brewery) .	"WM. GRAYBURNE."
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WITNEY, Oxon	"J. W. CLINCH."
YEOVIL, Somerset	"THO. CAVE."

ASHFORD, Kent.—"I have been much pleased with the perusal of your work, the 'Theory and Practice of Brewing,' and think it well worth the attention of all that have to do with brewing. THOMAS ELLIOTT."

AUCKLAND (West), Durham.—"My opinion with respect to your publication is, that it is a very useful book, and treats of subjects that would not have been known in this part of the country. HENRY HENDERSON."

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BATH, Somerset (Batheaston Brewery).—"I approve of your Treatise on Brewing very much; and I only wish I had the local means to adopt the whole of your improvements, and particularly the *Mashing Attemperator*.

"J. NEATE."

BIRMINGHAM, Warwick (Ashted Brewery).—"I have finished perusing your valuable Treatise on Brewing, which I have read with much pleasure; and, Sir, I am happy to acknowledge that I consider it a very accomplished work, and one from which I have gleaned some very useful information. I wish you every success, which I am sure your Treatise merits.

"J. R. MARRIAN."

The same in substance as one or other of these are the letters received with the subjoined signatures:—

BALDOCK, Herts	"C. J. MATHEWS."
CHESTER	"W. J. SELLER."
CLIFTON, Bedford	"S. WILSON."
DUNSTABLE, Bedfordshire	"W. GWILLT."
HARTLEPOOL, Durham (Newburn Brewery)	"M. E. GILLES."
MALTON, Yorkshire	"R. F. KINGSTON."
PUTNEY, Surrey	"JOHN WOOD."
RYE, Sussex	"WM. AYLWARD."
TENTERDEN, Kent	"CHAS. WICKER"
WANDSWORTH (Distillery), Surrey . . .	"T. BROSNER."

CANTERBURY, Kent (St. Augustine's Brewery).—"I can but say that, without exception, it is in my opinion the most useful and scientific I have ever met with, and shall feel great pleasure in again placing myself as a subscriber for the forthcoming edition. GEORGE BEER."

The author is particularly obliged to Mr. BEER, and likewise to Mr. W. CUTLACK of LITTLEPORT, Camb., who has favoured him with a similar order and testimonial.

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"H. T. COULTER."

To the same purport, and somewhat to the same extent, letters are received from
OLDBURY, Salop (Handsworth Brewery) . . . . "J. HORTON."
SHEFFIELD, Yorkshire (Pond Street Brewery) . . "W. BIRKS."

CHELTENHAM, Gloucestershire.—"I regret not having met you at Nine Elms when in London, much wishing to have seen your new invention to the mash-tun in operation. Your Treatise on Brewing and Malting I have read through, and consider it a work of great research, and from which every brewer may obtain very useful information. Should there be any thing new added in the second edition, I shall be happy to take a copy. I hope, when I can spare the time to visit London again, to be fortunate enough to meet with you. JOHN BULL."

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"JAMES LAWRENCE."

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DARTFORD, Kent.—"I have read your Treatise on Brewing, and can with confidence recommend it generally, as containing a vast quantity of useful information. Your arrangements, were they to be fully carried out, will, I have no doubt, prove highly advantageous. W. PITTOCK."

DARTMOUTH, Devon.—"We have derived much information from the perusal of your Treatise. The principles laid down we believe to be correct. In a word, we highly approve of the work, and strongly recommend it. BAKER, BROTHERS, & Co."

The author tenders his best thanks to the firm, and in like manner, for the like kind service, to the annexed:—

HOUGHTON-LE-SPRING, Durham . . . "JOHN LIDDLE."
TENTERDEN, Kent . . . . "GEO. COWELL."

EPSOM, Surrey.—"The perusal of your truly valuable Treatise on Brewing has afforded me great satisfaction; and it is with feelings of more than an ordinary degree of pleasure that I contribute my conscientious opinion of its merits. Its compilation must have cost you immense labour, and undoubtedly it stands unrivalled as a work of deep research and chemical knowledge, being scrupulously correct in every particular: in short, it may be said to contain a *mine* of information, treating copiously as it does of every subject connected with the trade, and alike interesting to the public and the private brewer. I shall look anxiously for the appearance of the forthcoming edition. Of the patented apparatus described in the work, I have seen the 'Mashing Attemperator,' and consider it to be unquestionably the greatest modern improvement introduced into the brewery: its adoption will, I have no doubt, become universal, when the advantages arising from its use are more fully made known. G. K. KING."

High and flattering testimonials of the scientific character and general utility of the work have also been received from

LIMERICK, Ireland . . . . . . "MATTHEW FITT."
NEWHAVEN, Sussex . . . . . "C. W. FOWNER."
and WAKEFIELD, Yorkshire . . . . "JNO. YOUNG."

The letter from Mr. Fitt, who is of the Society of Friends, is very pleasing; and Mr. Young notices, in common with Mr. Lawrence and others, that the contents are calculated to "awaken a spirit of inquiry" in the trade.

GOSPORT, Hants.—"With regard to your Treatise on the art of Brewing, I am of opinion that it is a most valuable work, and cannot be too highly appreciated: in fact, every brewer and maltster ought to possess a copy. I hope it will gain an extensive circulation, and in some measure recompense you for the talent evinced. I hear your work highly spoken of by all who have perused it. F. GOODEVE."

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"J. M. THORNE."

LONDON: late of the Old Street Brewery, "JAMES RUDGE," writes to the same effect.

LONDON: Wandsworth Road (Patent Brewery).—"I have read your Treatise on Brewing with an infinite deal of pleasure and advantage; and after mature deliberation I am so fully convinced of the correctness of the principles there laid down, that I have come to the conclusion of adopting your machines and plans in the Brewery I am now erecting, as far as the locality of the ground will admit, and I have no hesitation in saying, that the time is not far distant ere such principles will be generally adopted.

"HENRY LOVIBOND."

LOUTH, Lincoln (Phœnix Brewery). — "It is with infinite pleasure that I give my conscientious opinion, which was formed on the first careful perusal of your work, six months ago. I have had no occasion to alter the high opinion I then entertained of it. I consider it the first Treatise on Brewing which has really placed the art on its proper pedestal, and appropriated to it a niche in the Temple of Science.

"I believe a day will come when the theories you have propounded shall be received as established truths: they have their origin in unerring principles; and to overthrow the superstructure you have raised, the settled basis of such men as Liebig, Berzelius, Saussure, our own Turner, and a host of others, must be annihilated.

"The author of the critique in the Brewer's Annual for 1844, shows his good sense in the very candid acknowledgment that his capacity is unequal to understand one half of it. Perhaps it would have been as well had the criticism ended here. Had Newton given his sublime discoveries to none but *ordinary* minds, he would have unfolded 'all nature's laws' to no purpose beyond his own gratification. ST. JOHN WELLS LUCAS."

MAIDENHEAD, Berks.—"I have enclosed a P. O. O. 25*s*. for Tizard's Practical Treatise on Brewing, &c. The work contains more real scientific and practical knowledge on brewing than any book I have ever yet met with on the same subject, and it cannot fail of being an esteemed companion to all those who are practically engaged therein. Eventually the system developed will become generally adopted by the trade.

"RT. NICHOLSON."

MAIDSTONE, Kent.—"From your book on the system of brewing, I can safely say I have learned more than from all the other books I ever read on the subject put together; and if I were commencing the building of a brewery, I should certainly adopt most of your improvements. I believe that what you have written will cause the science to advance with rapid strides. W. FISH."

MAIDSTONE (Medway Brewery).—" *** I have carefully perused your work on Brewing, and I do consider that your system therein illustrated, both practical and theoretical, is the best, and based upon the soundest and most philosophical principles of any work I have ever met with.
"H. GODDEN, Jun."

MILBOURN ST. ANDREWS, Dorset (Milton Brewery). — "I have perused your Treatise with much interest, and am so far satisfied with the soundness of your practical experience and depth of scientific research, that I have recommended it to many of my friends. The extended sale which you must have, will, I am of opinion, convince you that the brewing world, as a body, are neither slow in appreciating merit nor backward in adopting improvements. C. WARNE."

NEWPORT, Isle of Wight.—" Having carefully read and greatly profited by your instructions in the various departments of the Brewery, I should deem myself most ungrateful not to acknowledge how greatly I am indebted to you for your elaborate and highly useful publication. Since I have attended to your instructions I have been able to obtain a much better extract from my goods than I ever did before, unless it was occasionally and by accident; but now I proceed with certainty and success. Accept, therefore, my sincere thanks. BARNABAS EXTON."

NEWTON BUSHELL, Devon (Mill Lane Brewery).—"We do most cordially approve of your Treatise on Brewing, and have met with other brewers who have been very much pleased with the work. Wishing you success in your second edition, we have to beg pardon for our delay.
"PALK & PINSENT."

NOTTINGHAM (Carrington Brewery).—" We have perused your work on brewing, and have much pleasure in stating our gratification with its contents.

" We are bound to say that all the important points are justly and elaborately treated upon in a scientific and practical manner, and, in our opinion, it conveys information upon the subject more directly than any other work we have yet met with. BEASLEY & CHAMPION."

OAKHAM, Rutland (George Brewery).—"I have perused it both with pleasure and profit. Your theory of the saccharine conversion is fully borne out, both by the instrument, and the quality of the ale produced by the process: in fact, the merits of the system require only to be understood to be generally adopted; and every brewer who studies his business must welcome the Attemperator as a most valuable auxiliary. You will, doubtless, meet with opposition from interested and prejudiced persons; but I am convinced that every brewer who neglects to avail himself of the Patent Mashing Attemperator, is blind to his own interest. I trust you will not come to Stamford without paying us a visit. J. CROWSON."

PLYMOUTH, Devon (Hoe-gate Brewery).—"I assure you that I feel happy to have an opportunity of expressing the high opinion that I entertain of your work, and my conviction of the vast obligation you have imposed upon all in any way connected with the brewing trade. The perusal of it has afforded me more gratification than any work upon the subject that I have before met with, and I feel bound to admit, that notwithstanding my long experience, I am indebted to it for several very valuable and useful

hints. Your Mashing Attemperator and Hystricon I think very highly of, and have no doubt that sooner or later they will be generally adopted. The merit of your book, and the extensive information it displays, would afford me a never-failing theme, but at present I regret to say I have not time to dwell upon them. SAMUEL MATTHEWS."

PORTSMOUTH, Hants.—"I can have no other feeling than that of pleasure in conveying to you my unqualified approval of the deep research your work evinces throughout, and that such a book has long been wanted in the trade. This approval may perhaps be of more value when I inform you that I have been above twenty years a brewer, and am brother to J. C. Wood of Westminster, where I had the whole brewing management for very many years, and left only from ill health, and was succeeded by a Mr. Amsinck. I am only surprised at the opinion he expresses in the Brewer's Annual, when I *know* he has only learnt his business where he now is. You may send me three copies of your second edition. FREDERICK WOOD."

SLEAFORD, Lincoln (Albion Brewery).—"I beg to say that I have perused your volume, and am delighted with it. I do believe it to be *decidedly* the *best* publication on brewing I have ever seen; and if my opinion, which is that of a person who has been upwards of fourteen years engaged in the brewing department, both practically and experimentally, can afford you any gratification, I feel bound, as an honest man, to say that I consider it a very valuable work, affording instruction to young beginners, and information to experienced men. C. HEPPENSTALL."

SOUTHEND, Essex.—"I feel great pleasure in offering my humble tribute of praise to your incomparable Treatise on Brewing. I have read other treatises, but none to compare with yours. No brewer ought to be without a copy, and I may say, now that I have read it, that I should by no means have considered the money ill bestowed if the price had been five guineas.
"JOHN HUDSON."

SOUTHOVER, Lewes, Sussex.—"Being a young man, I cannot but feel a delicacy in passing an opinion on this work; but still I *have* an opinion, which I unhesitatingly give. Many brewers of the old school, and even those of the present day who are following their rules and dogmas, will be startled at so many new schemes, but not until they prove by experiment and reason that you are wrong, ought they to express their dissent. Your work contains a vast deal of practical knowledge on brewing, and I have no doubt, all into whose hands it may come will agree with me that we have much to learn. I strongly recommend those who may consult it, not to be satisfied with merely 'skimming' its contents, but to give it their best attention, and the result will be a good 'extract' of information. GEORGE NORMAN."

STAMFORD, Lincoln (Patent Steam Brewery).—"I have read your work with pleasure, and feel so fully convinced of the truth of a quotation contained in it: 'No man is under the necessity to know every thing, but they that have particular callings ought to understand them;' that notwithstanding the numerous works already published on Malting and Brewing, such an additional light is thrown upon the subject by your publication, that I would recommend every brewer to possess it, in order that he may *better*, indeed I might say, that he may *thoroughly* understand his business. It is the best and completest work with which I am acquainted.
"WILLIAM EDWARDS."

TAVISTOCK, Devon.—"As far as I have been enabled to carry out the principles of the Treatise, my most sanguine expectations have been realized, and I am persuaded, were they generally adopted, our national beverage would be universally drunk and admired. JOHN WHITE."

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GILBERT & RIVINGTON, Printers, St. John's Square, London.